R Andersen

MODEL DY-2401C
INTEGRATING DIGITAL VOLTMETER

Use For Serial Numbers Indicated On Page ii)

OPERATING AND SERVICE MANUAL

HEWLETT PACKARD DYMEC DIVISION

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

HANDBOOK
for

MODEL DY-2401C INTEGRATING DIGITAL VOLTMETER

(Use For Serial Numbers Indicated On Page ii)

DY-2401C with autoranging (Option M31)

DYMEC
A Division of Hewlett-Packard Co.
395 Page Mill Road, Palo Alto, California

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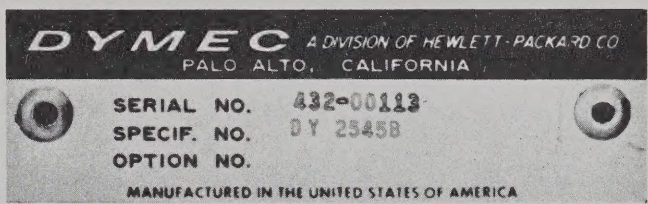
IMPORTANT

THIS HANDBOOK
APPLIES TO INSTRUMENTS BEARING SERIAL PREFIX 501- **AND**
INCLUDES OPTIONAL MODIFICATIONS:
Within handbook:

At rear of handbook:

INSTRUMENT IDENTIFICATION

Each instrument is identified by a two-section, 8-digit Serial Number, stamped on a plate attached to the rear panel (or a side panel).



The first 3 digits are a Serial Prefix (type) Number, the last 5 digits identify each individual instrument. ALL INSTRUMENTS WITH THE SAME SERIAL PREFIX ARE THE SAME. Later instruments (higher Serial Prefixes), are covered by a green "Updating Supplement", at the back of each handbook. Earlier instruments (lower Serial Prefixes), are covered by a blue "Backdating Supplement", also at the rear of the handbook.

Option No(s). identify Modifications made to the basic equipment to meet your particular requirements. Some Optional (standard) Modifications may be described within, or at the rear of the handbook as listed above.

MODIFICATION DESCRIPTIONS

Any special Modifications to the equipment described in this handbook are explained in "Handbook Supplements" added at the rear of this handbook.

READ through Section 2 of the basic handbook and all accompanying "Handbook Supplements" before attempting installation or operation of your equipment, as some special procedures may be necessary.

QUICK REFERENCE INDEX

To locate desired data quickly, bend the handbook back to expose the index marks on the first pages of all the sections. These marks correspond to index marks on this page.

OPTIONAL MODIFICATIONS

HANDBOOK SUPPLEMENTS

CONTENTS

NOTE

The contents of the remaining Sections of this handbook are listed just before the first page of each Section (except for Section 5).

SECTION 1
GENERAL DESCRIPTION

1.1 BASIC CAPABILITIES

The DY-2401C Integrating Digital Voltmeter is an all solid state electronic instrument which measures dc potentials up to ±1000 volts. The lowest of the instrument's five decade multiple voltage ranges is a ±0.1 volt range that permits high-resolution millivolt measurements. In addition to voltage measurements, the DY-2401C is capable of frequency measurements from 5 cps to 300 kc. Measurements are indicated on a direct reading 6 digit display that is accompanied by an identification display of the units being measured and input polarity.

The measurements and units are made available in 4-2'-2-1 binary-coded decimal (bcd) for recording by a digital printer or for further digital data processing. Other capabilities may be added to the standard instrument in the form of various accessories and modifications which are discussed briefly in Sections 1.4 and 1.5.

1.2 FUNCTIONAL DESCRIPTION

Basically, the DY-2401C consists of a precise input attenuator, a highly-accurate, highly-linear V-F (voltage-to-frequency) converter, and a frequency counter. The V-F converter has separate outputs, one produced in response to positive input, the other produced in response to negative input. The frequency counter counts the pulses from the V-F converter for one of three specific sample periods, producing a count that is directly proportional to the average input voltage to the DY-2401C. The sample periods of the DY-2401C, .01, .1, and 1 second, are produced by decade division of the output from a 100 kc reference oscillator. The counter can be used alone for frequency measurements, as noted previously.

1.3 DESIGN FEATURES

1.3.1 Averaging of Positive and Negative Excursions

During voltage measurements, the decade counters in the DY-2401C can count either forward or backward under the control of special logic -- averaging the positive and negative excur-

sions of the input algebraically. Regardless of the polarity of the input, the counters count forward initially. Reversal of the input polarity switches the counters to a backward count. At the backward count of zero, the counters are switched to counting forward and the polarity logic is switched. The count at the end of the sample period is the algebraic sum of the voltage-time integrals of the positive and negative signals tagged with the signal polarity that has the greatest voltage-time integral.

1.3.2 Noise Rejection

The DY-2401C design virtually eliminates voltage measurement errors caused by extraneous noise. This is accomplished without imposing any restrictions on the grounding of the signal source or the grounding of any interface equipment. The greatest noise rejection is achieved by using a floating and guarded v-f converter that eliminates common mode noise. Further noise rejection is achieved by the input averaging design of the DY-2401C. Combined, these techniques yield an effective noise rejection greater than 140 db (10 million to 1) at all frequencies, including dc.

Induced ac ground currents, usually at power line frequency, can generate a potential of several volts between the signal source ground and the voltmeter chassis ground. If not blocked these currents will cause a voltage larger than the signal to appear at the input, resulting in a completely erroneous reading. To prevent this effect, known as common-mode pickup, the DY-2401C features a shield or 'guard' that completely isolates the measuring circuit from the instrument chassis. The guard breaks the common mode loop. With the DY-2401C operated at the ground potential of the signal source, common mode rejection (defined as the ratio between the common mode signal and the spurious voltage it causes to be superimposed on the signal to be measured) exceeds 120 db at 60 cps and 160 db at dc with a 'ground leg' impedance of 1000 ohms between the source ground and the low side of the voltmeter input. The combined effect of guarding and averaging is such that a common mode potential of 100 volts will not cause a discernible error in the DY-2401C reading.

To reduce superimposed noise, the DY-2401C, by means of active integration, reads the average value of the applied voltage over a fixed sample period. When the average value of superimposed noise is zero over the selected sample period, no error caused by superimposed noise appears in the measurement. (See

Section 1.7, Specifications for a graph of noise rejection versus noise frequency for the fixed sample periods that are provided in the DY-2401C.)

1.3.3 Overranging

Overranging to 300% of full scale is permissible on every range except the 1000 volts range. This provides additional resolution and accuracy on readings that are within the overranging capability. If the instrument is accidentally overloaded beyond 300% of full scale, the input attenuator is switched automatically to the 1000 volts range. This occurs at approximately 310% of full scale. The overload condition is indicated on the units display and on the recording output. The instrument resets automatically when it starts taking the next sample. If the overload condition persists, the protective cycle and overload indication are repeated.

1.3.4 Manual Control of Display Duration and Sampling Rate

At the end of the sample period, the display and recording outputs can be held for a period that is adjustable from 200 milliseconds to 7 seconds. At the end of this period, the DY-2401C will take a new sample. The sample-hold cycle will repeat indefinitely. The repetition rate of this cycle and the duration of the display period are set by the SAMPLING RATE control on the front panel.

1.3.5 Adaptability to Data Acquisition Systems

To facilitate its use in data acquisition systems, the DY-2401C has been designed to be completely programmable. Programming is accomplished simply, by means of external contact closures to ground. The following may be programmed:

1. Measurement function (volts, frequency, or other functions added by accessories or modification of the standard instrument).
2. Voltage range.
3. Sample period.

System cabling is simplified because input, programming, and bcd output connections are made at the rear of the instrument.

Data acquisition system programming of the DY-2401C can by-pass the SAMPLING RATE control on the front panel. The maximum sampling rates then depend upon selection of the sample period. The .01 second sample period most frequently used for data acquisition systems permits a maximum of 50 readings per second. Nine readings per second are possible when the .1 second sample period is selected. This sample period provides the optimum combination of speed, resolution, and accuracy for most measurements. The 1 second period, providing about 1 reading per second, is useful where maximum resolution is required.

1.3.6 Control of Sample Period

The input signal can be integrated over one of the fixed sample periods, or over an extended period which may be started manually or by programming. In this way analog signals from transducers can be integrated over any desired time interval, permitting totalization of flows, pressures, or other quantities.

1.3.7 Self Checking

A precision internal ±1 volt reference source is provided for checking the calibration of the DY-2401C. The internal standard is obtained from a specially aged, temperature stabilized Zener diode that is selected for less than 0.01% drift in 6 months. The provision of this internal standard permits in-place calibration, avoiding frequent unracking and transportation of the instrument to the standards laboratory.

The DY-2401C design also provides for a self check of forward counting and decimal point logic.

1.4 CAPABILITIES PROVIDED BY ACCESSORIES

1.4.1 DY-2410B AC/Ohms Converter

The DY-2410B AC/Ohms Converter adapts the DY-2401C for ac voltage measurements to 750 volts peak and resistance measurements to 10 MΩ. Visually,the units display of the DY-2401C includes the Ω, KΩ, MΩ, AC readouts that are observed during resistance or ac voltage measurements using the DY-2410B.

1.4.2 DY-2411A Guarded Data Amplifier

The DY-2411A Guarded Data Amplifier adapts the DY-2401C for low level, high input impedance measurements. The DY-2411A/DY-2401C combination affords ±10 millivolts full scale input, with overranging to 30 millivolts. Correct positioning of the decimal point is provided by an assembly (A30) that is supplied with the DY-2411A to be plugged into the DY-2401C.

1.5 CAPABILITIES PROVIDED BY MODIFICATIONS

A variety of standard optional modifications to the DY-2401C are available. These modifications are summarized briefly as follows.

M18. Fits the DY-2401C with Chassis-Trak C-300-S-20 slides. This facilitates calibration and servicing of rack mounted instruments.

M21. Provides positive-true 8-4-2-1 bcd recording outputs instead of the 4-2'-2-1 bcd recording outputs supplied by the standard instrument.

M29. Allows frequency measurements to 1.2 mc.

M30. Adds period measurement capability. Full scale periods of 1, 10, and 100 milliseconds may be measured.

M31. Adds automatic ranging capability. The DY-2401C automatically selects the appropriate range on receipt of a read command signal. Range selection begins at the range selected for the previous reading and proceeds directly to a higher or lower range as required. Nominal time for range change is 6 milliseconds. Maximum time from the read command to the start of the sample period, allowing change from lowest to highest range or vice versa, is 34 milliseconds.

During measurement of varying signals, the DY-2401C upranges if the signal exceeds 310% of full scale during the sample period. A new sample period is then started automatically. The record command at the end of

the aborted sample period is suppressed. The instrument does not downrange if the input falls below 25% of full scale during the sample period. This ensures that the DY-2401C will always arrive at a valid reading even in the presence of considerable superimposed noise.

The autoranging mode is selected by a front panel switch or by an externally-programmed circuit closure to ground. Autoranging also selects the appropriate gain (+1 or +10) for the DY-2411A Guarded Data Amplifier when it is used with the DY-2401C.

M35. Provides negative-true 8-4-2-1 bcd recording outputs instead of the 4-2'-2-1 positive-true bcd recording outputs supplied by the standard instrument.

M70. Transducer measurements reading directly in engineering units such as °C, psi, gpm are possible with Option M70 to the DY-2401C and an accessory instrument, the DY-2417A Data Linearizer. In addition to scaling the transducer output and compensating for transducer zero offset, the DY-2417A also corrects for non-linearity in the transducer response. (DY-2417A data sheet available.)

1.6 PHYSICAL DESCRIPTION

The DY-2401C mounts in a standard 19-inch rack and requires 7 inches of vertical panel space. It extends to a depth of 18-3/8 inches (including the externally-mounted cooling fan). The instrument chassis is made of alodined aluminum, and the front panel is finished in light-grey baked enamel with black-filled engraved titles.

SPECIFICATIONS

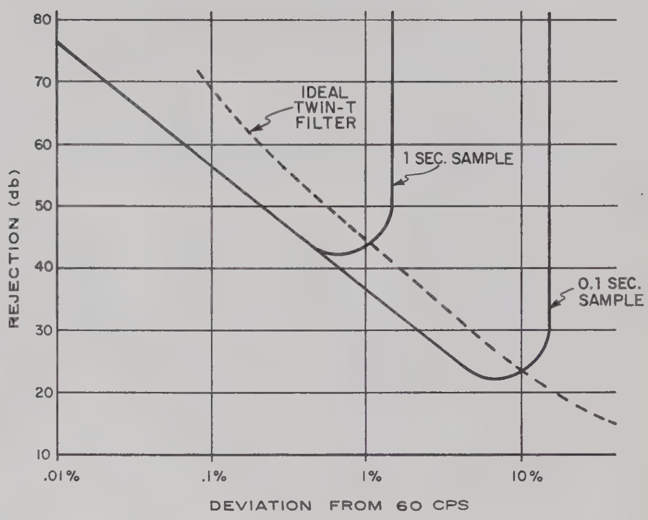
DC VOLTAGE MEASUREMENTS

NOISE REJECTION

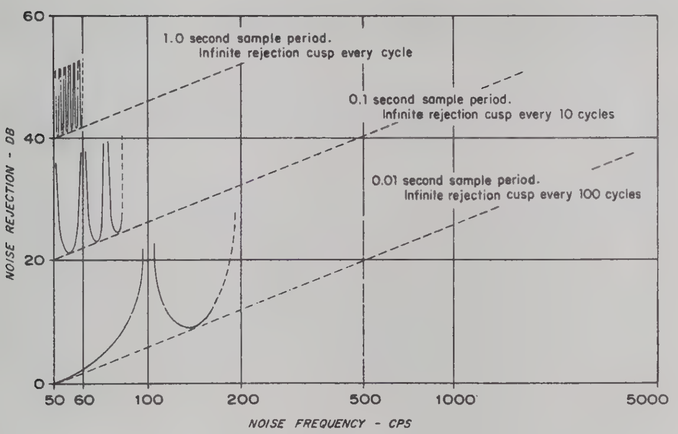
Overall Effective Common Mode Rejection: (ratio of common mode signal to its effect on digital display): 140 db at all frequencies, 160 db at dc (0.1 second sample period).

Common Mode Rejection: (ratio between common mode signal and voltage it superimposes on source): 120 db at 60 cps, 160 db at dc, with 1000 ohms between low side of source and low side of voltmeter input (resistances up to 10K permissible).

Superimposed Noise Rejection: (ratio of superimposed noise to its effect on digital display): More than 20 db at 55 cps for 0.1 second sample period; increases 20 db per decade increase in frequency. Infinite rejection at frequencies evenly divisible by 10. (For 1 second and 0.01 second sample periods see graph below.) Combined amplitude of signal and superimposed noise can equal ±3 times full scale, for any signal amplitude.



REJECTION AROUND 60 CPS



SUPERIMPOSED NOISE REJECTION

INPUT CIRCUIT

Type: Floated and guarded signal pair. Signal pair and guard may be operated up to 500v above chassis ground.

Ranges: 5 ranges from 0.1 to 1000v full scale (see also 'Resolution' on page 6). 10 mv range with accessory DY-2411A Amplifier. Range selection by front panel switch or remote circuit closure to ground. See page 6 for specifications of optional Autoranger. Signal polarity sensed automatically.

Overranging: Overranging to 300% of full scale permissible, except on 1000v range. Attenuator switches automatically (in 3 ms) to 1000v range if overload exceeds 310%. Reset automatically by next internal or external read command signal.

Input Impedance: 10M on 10, 100, 1000v ranges. 1M on 1v range. 100K on 0.1v range. Impedance is within ±.02% of nominal value, all ranges. <150 pf all ranges.

Connectors: Front panel binding posts (3/4" centers) for HI, LO and Guard. Alternate input via guarded connector on rear panel.

▲ACCURACY

±.01% rdg ±.005% fs ±1 digit (0 to fs)
±.02% rdg — ±1 digit (at 2 x fs)
±.025% rdg — ±1 digit (at 3 x fs)

Specification holds for all ranges, ±10% line voltage change, and 6 months operation. Assumes daily calibration against internal standard, operation at 25°C.

Temperature Coefficient:
±.001% rdg per °C, 10 to 40°C
±.0015% rdg per °C, 40 to 50°C

When calibrated against internal standard at operating temperature.

±.002% rdg ±.0005% fs per °C (0.1v range).
±.002% rdg ±.0002% fs per °C (1/10/100/1000v ranges).

When not calibrated at operating temperature, over range 10 to 50°C.

▲INTERNAL CALIBRATION SOURCE

±1 volt internal standard provided for self-calibration. Voltage reference is derived from specially aged, temperature stabilized zener diode. Proven selection criteria guarantee drift of less than ±.006% in six months. Internal standard may be compared and adjusted against external standard. Factory-adjusted to better than ±.002% absolute accuracy at 25°C. Temp. coeff. ±.001% per °C, 10 to 40°C, ±.0015% per °C, 40 to 50°C.

MEASUREMENT SPEED

Fixed sample periods of 0.01, 0.1 or 1 second may be selected by front panel switch or remote circuit closure to ground. Sampling rate determined by delay between samples, adjustable at front panel from 0.2 to 7 seconds. (Max. speeds shown in Table.)

RESOLUTION

Depends on sample period selected -- see Table.

Max. resolution is 1 microvolt per digit (0.1v range, 1 second sample).

SAMPLE PERIOD	MEAS. SPEED	SELECTED RANGE (V)	FULL SCALE READING	RES.	MAX. OVERRANGE READING	RES.
1 SECOND	1 READING/SEC	0.1	100.000 MV	1 PART IN 10^5	300.000 MV	3 PARTS IN 10^6
		1	1000.00 MV		3000.00 MV	
		10	10.0000 V		30.0000 V	
		100	100.000 V		300.000 V	
		1000	1000.00 V		—	
0.1 SECOND	9 READINGS/SEC	0.1	100.00 MV	1 PART IN 10^4	300.00 MV	3 PARTS IN 10^5
		1	1.0000 V		3.0000 V	
		10	10.000 V		30.000 V	
		100	100.00 V		300.00 V	
		1000	1000.0 V		—	
0.01 SECOND	50 READINGS/SEC	0.1	100.0 MV	1 PART IN 10^3	300.0 MV	3 PARTS IN 10^4
		1	1.000 V		3.000 V	
		10	10.00 V		30.00 V	
		100	100.0 V		300.0 V	
		1000	1000.V		—	

NOTE: POLARITY SENSED AND INDICATED AUTOMATICALLY.

AUTORANGER

VOLTAGE RANGES

Automatically selects appropriate range from 5 input ranges of standard instrument (0.1v to 1000v full scale) on receipt of read command signal. Starts at range selected for previous reading, proceeds directly to higher or lower range as required. Autoranger also selects appropriate gain setting (x1 or x10) when DY-2401C is used with DY-2411A Amplifier.

RANGE CHANGE POINTS

Upranges at 310% of full scale,
Downranges at 30% of full scale.

RANGE SELECT TIME

6.0 ms (nominal) for each range change. When correct range is reached there is an encode delay of 9.7 ms before sample period commences. Max. time from receipt of read (encode) command to start of sample period, allowing autoranger to travel from lowest to highest range or vice versa, is 34 ms.

VARYING SIGNALS

Upranges if signal increases beyond 310% of full scale during sample period and starts new sample (record command at end of aborted sample period is supressed). Does not downrange if signal decreases below 30% of full scale during sample period. This technique ensures that voltmeter will always arrive at valid reading, even in presence of very severe superimposed noise.

MODE SELECTION

Autoranging mode selected by front panel function switch or external circuit closure to ground, applied at programming input connector.

DC VOLTAGE INTEGRATION

Input signal is integrated over selected sample period. Using fixed sample period (1, 0.1 or 0.01 second) integral corresponds to average of input, readout is in volts. Alternatively, sample period may be started and stopped by front panel switch or remote signal (see External Programming) in which case display reads in millivolt-seconds or volt-seconds as appropriate.

Note: Instrument displays true integral with correct polarity, even if signal crosses through zero during sample period.

Ranges:

0 to 100.000 millivolt-seconds
1000.00 millivolt-seconds
10.0000 volt-seconds
100.000 volt-seconds
1000.00 volt-seconds

Accuracy: Same as for DC Voltage Measurement, with exception that errors given as percent of full scale must be multiplied by the integration time in seconds.

FREQUENCY MEASUREMENTS

Range: 5 cps to 300 kc. To 1.2 mc with Option M29.

Gate Time: 0.01, 0.1, 1.0 second or manual control (front panel switch or remote signal, see External programming).

Accuracy: ±1 count ±time base accuracy.

Internal Time Base: Stability at constant temperature (±5°C) is $\pm 2/10^6$ per week. Temperature effect is $\pm 100/10^6$ over range 10 to 50°C. (Self-check control on front panel for counting internal 10 kc for selected gate time.)

External Time Base: Rear BNC and switch provided for external frequency standard. Level required is 2v p-p into 1.2K.

Display Time: Continuously variable from 0.2 to 7 seconds, or held continuously until reset either manually or by remote signal (see External programming).

Input Sensitivity: 0.1 to 100v rms (front panel attenuator) or will accept negative pulses, 1v min. amplitude, 2 μs min. width. (Sensitivity decreases to 0.5v rms at 1 mc, with Option M29 installed.)

Impedance: 1M shunted by 100 pf.

Connector: BNC on front and rear panels.

PERIOD MEASUREMENTS

(Option M30)

▲ Ranges: 1, 10 and 100 periods, 5 cps to 10 kc.

Display: Reads directly in milliseconds. (Recorder output in ms × 10^{-x}, where x is range digit recorded.)

Resolution (referred to single period):

1 period	100 μs
10 periods	10 μs
100 periods	1 μs

Accuracy: ±1 count ±time base accuracy, ±trigger error divided by number of periods averaged.

For time base accuracy see 'Frequency Measurements'. Trigger error for 0.1v rms sine-wave input is 0.3% for signals with 40 db signal/noise ratio. Trigger error decreases with increased signal amplitude and slope.

Sensitivity, Impedance, Connector: Same as for 'Frequency Measurements'.

Mode Selection: By front panel function switch or external circuit closure to ground, applied to programming input connector.

GENERAL SPECIFICATIONS

DISPLAY

6 digit Nixie readout (5 full scale digits plus overrange digit). Polarity, decimal point, function and overload condition indicated automatically. (This also applies when DY-2401C used with DY-2410B AC/Ohms Converter.) Rear switch provided to select 'Store' or 'Display' during count period.

RECORDING OUTPUTS

Binary-coded decimal outputs provided as follows:

Function:	1 digit
Data:	6 digits
Decimal point:	1 digit

(Decimal point digit indicates negative exponent, e.g. for reading of 137.58 volts, or 13758×10^{-2}, output is digit "2".)

Outputs will drive ⓗⓟ562A Digital Recorder directly, or other devices either directly or through a Dymec coupler. Table shows printout of a special printwheel supplied with J66/5-562AR for recording function.

DATA	FUNCTION	LOGIC 4-2'-2-1	-hp- 562A PRINTWHEEL STD.	-hp- 562A PRINTWHEEL No.4610
0	PERIOD ††	0 0 0 0	0	P
1	+ VDC	0 0 0 1	1	+
2	− VDC	0 0 1 0	2	−
3	KC	0 0 1 1	3	F
4	KΩ †	0 1 1 0	4	K
5	MΩ †	0 1 1 1	5	M
6		1 1 0 0	6	>
7		1 1 0 1	7	<
8	TIME	1 1 1 0	8	T
9	OVERLOAD	1 1 1 1	9	Q
		1 0 0 0	BLANK	BLANK
	VAC †	1 0 0 1	—	A

† WHEN DY-2401C USED WITH DY-2410B AC/OHMS CONVERTER.
†† WITH DY-2401C OPTION M30.

▲ BCD Outputs:

VOLTAGE LEVELS	"0"	-35 TO -24.5V
	"1"	-2.5 TO 0V
SOURCE IMPEDANCE	DATA	100K
	FUNCTION, DEC. PT	33K
MAX. CURRENT	DATA	0.3 MA
	FUNCTION, DEC. PT	1 MA

▲ Record Command: Level '1' for record and '0' during sample period, or vice-versa. (See below.)

REFERENCE	"0"	"1"
LEVEL	-24.5 TO -21.5V	-5 TO -1V
IMPEDANCE	5000 Ω	1000 Ω
MAX. CURRENT	1 MA	15 MA

▲ ⓗⓟ562A Printer Reference Voltages:

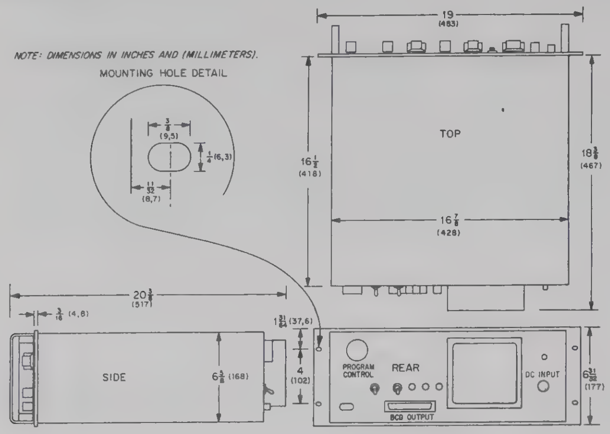
REFERENCE	"0"	"1"
LEVEL	-24.5 TO -21.5V	-5 TO -4V
IMPEDANCE	800 Ω	380 Ω
MAX. CURRENT	1 MA	0.5 MA

Connector: Amphenol 57-40500 50-pin connector on rear panel.

FREQUENCY OUTPUT

Internal 100 kc frequency standard is available at rear BNC. (Square wave, 0 to -1.2v, 1K source impedance.)

DIMENSIONS



EXTERNAL PROGRAMMING

DY-2401C may be completely programmed by external circuit closures to ground. For maximum sampling speed, pulse input may be used for reset/encode command. Unless otherwise stated, all programming commands received via rear MS3102A28-21S 37-pin connector.

Function: DY-2401C normally measures voltage unless closure received on 'Frequency' command line.

Range: Separate closure required to select any one of the five voltage ranges. Range select time less than 6 ms.

Sample Period: Separate closure required to select any one of the three fixed sample periods or to energize 'Manual Control' line. When 'Manual Control' line energized, closure on 'Start/Stop' line opens gate. Alternatively, voltage level between +5v and -1v may be used to open gate, and between -5v and -30v to close gate. (Input resistance 4K.) Gate opens/closes within 1 μs of command.

Reset (Encode): Counter portion of DY-2401C may be reset and new count initiated by closure on 'Counter Reset' line. Alternatively, counter may be reset by -15v, 25 μs pulse (rise time <2 μs) applied to separate rear BNC. Fixed delay of 12.7 ms before start of new count with closure reset, 9.7 ms with pulse reset.

Hold: Positive voltage between +1 and +12v (max. load 4.5 ma) inhibits counter from initiating new count. Voltage between -1 and -35v enables count. Received via recorder (bcd) output connector.

▲ Circuit Closure to Ground: Defined as contact closure or equivalent which raises internal circuit to -1v or more positive level, capable of supplying max. current of 70 ma.

Accessory Amplifier: When used with DY-2411A Amplifier, decimal point logic card furnished with amplifier must be installed in voltmeter.

AC/Ohms Measurements: If used with DY-2410B AC/Ohms Converter, coupling cards supplied with converter must be installed in voltmeter. External programming of system (except pulse encode command) is accomplished through DY-2410B.

OPERATING CONDITIONS

Ambient temperatures 10 to 50°C, relative humidity to 95% at 40°C.

POWER REQUIRED

115/230v ±10%, 50 to 60 cps, 150 watts approx.

WEIGHT

Net wt. 48 lb (22 kg); shipping wt. 66 lb (30,0 kg) approx.

PANEL FINISH

Light grey baked enamel. Black-filled engraved control titles.

OPTIONAL MODIFICATIONS

(Order by M-number.)

M18. Rack-Mounting Slides: Instrument is fitted with Zero-Trak C-300-S-20 slides, permitting easy withdrawal from rack. Add $75.00.

M21. 8-4-2-1 BCD Output (Positive True). Supplied in place of standard 4-2'-2-1 output (same specifications). Add $135.00.

M29. 1 MC Frequency Range. Measures frequencies to 1.2 mc when used in counter mode. (Not available with M30.) Add $250.00.

M30. Period Measurements. Instrument reads multiple period averages of signals to 10 kc. Specifications listed on page 7. (Not available with M29.) Add $250.00.

M31. Autoranging. For specifications see page 6. May be ordered in new instruments, or factory-installed subsequently. When ordered with new instruments add $250.00.

M35. 8-4-2-1 BCD Output (Negative True). Supplied in place of standard 4-2'-2-1 output. Specifications approx. same as for 4-2'-2-1, except '0' and '1' state levels reversed. Add $200.00.

▲ M70. Readout in Engineering Units. Permits control of sample period, preset count, decimal point and units indication by DY-2417A Data Linearizer. Add $400.00.

ACCESSORIES AVAILABLE

(Order by stock number.)

▲ 1. ⓗⓟJ66/5-562AR Digital Recorder. For use with DY-2401C. Includes special printwheel, 10 bcd boards, dual input connectors with one input cable. J66-562AR (60 cps), stock number 0950-0069, $1,985.00. J65-562AR (50 cps), stock number 0950-0068, $2,000.00.

2. Programming Input Connector. MS3106B28-21P, 37-pin (with clamp) stock number 5060-2440, $8.75.

3. Recorder Output Connector. Amphenol 57-30500, stock number 1251-0086, $7.00.

4. Input Connector. Mates with rear guarded input connector, stock number 1251-0350, $6.00. (One connector is furnished with instrument.)

ACCESSORIES FURNISHED

1. Power Cable. Length 7-1/2 feet, plugs into rear connector. Stock number 8120-0078.

2. Input Connector. Mates with rear guarded input connector. Stock number 1251-0350.

3. Extender Boards. For servicing plug-in circuit boards. Set of five. Stock number 5060-5078.

PRICE

Model DY-2401C Integrating Digital Voltmeter, $3,950.00

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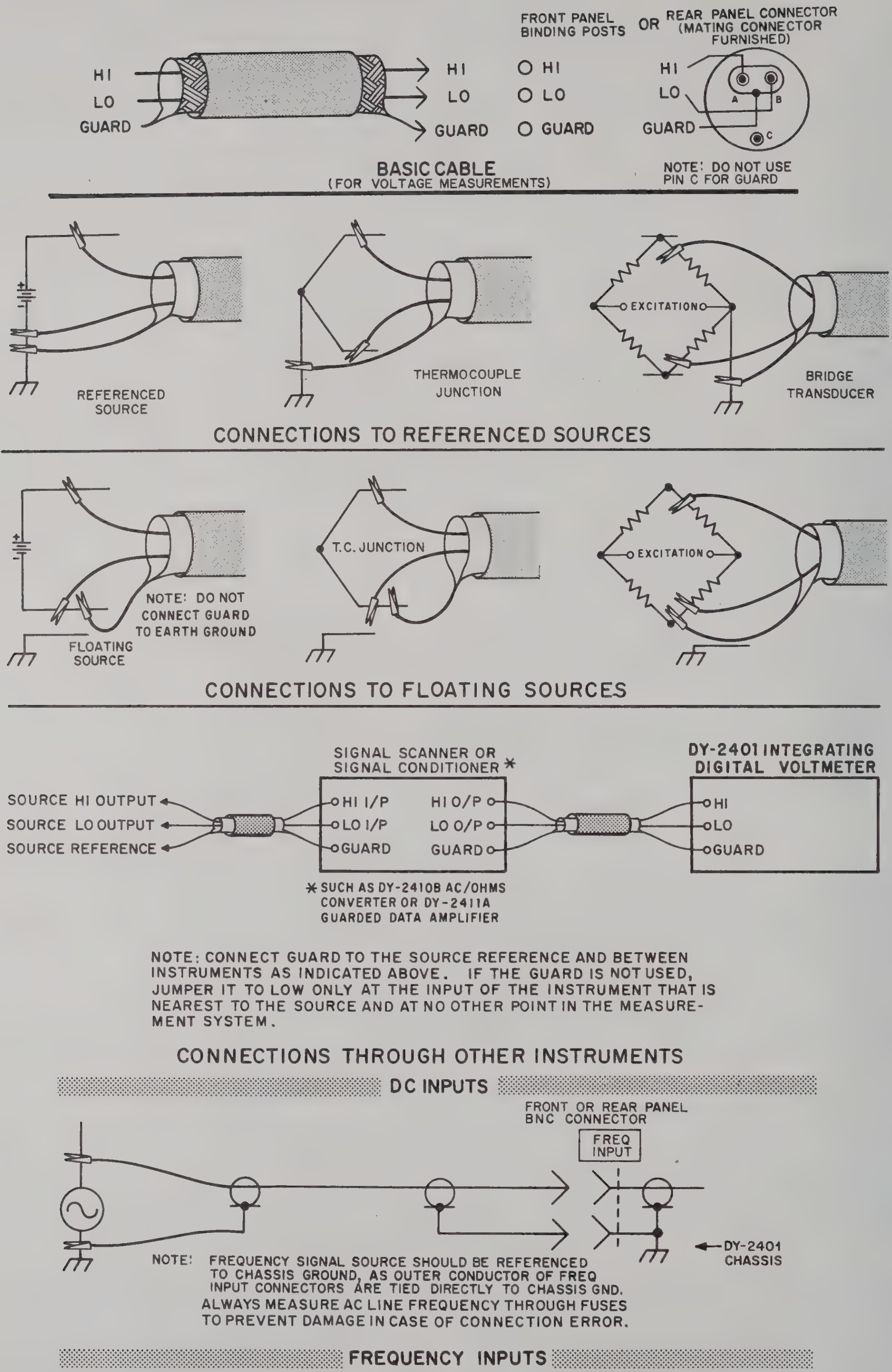


DY-2401C INPUT SIGNAL CONNECTIONS

FIGURE 2.1

SECTION 2
INSTALLATION AND OPERATION

2.1 INSTALLATION

The DY-2401C Integrating Digital Voltmeter mounts in a standard 19-inch wide rack, and is also suitable for bench-top use. For rack-mounting, 7 inches of vertical panel space is required. Depth required behind the front panel, including recommended cable clearances, is 21-3/8 inches. The DY-2401C contains its own cooling fan. No additional cooling facilities are required. Ambient operating temperatures can be as high as 50°C, and the relative humidity as high as 95% at 40°C.

A slide switch on the rear panel allows the DY-2401C to be operated from either a 115 volts or 230 volts 50 to 60 cps power source, without rewiring the primary connections on the power transformer. Power required is approximately 150 watts.

> CAUTION
>
> The position of the 115/230v slide switch and the ampere rating of the main fuse should be checked before application of power. When the instrument is shipped from the factory, the switch is normally set for 115 volts operation, and a 2 ampere slow-blow main fuse is installed. For 230 volts operation, change the main fuse to a 1 ampere slow-blow.

2.1.1 Input, Output, and Programming Connectors

DC Input: Binding post terminals on the front panel or special guarded connector (DC INPUT J31) on the rear panel. The HI and LO terminals receive the two-wire dc input voltage; the GUARD terminal (connected internally to the guard chassis) receives the reference potential of the measurement source. The signal pair and guard may be operated up to 500 volts above chassis ground. See Figure 2.1 for input signal connections and wiring of the special guarded connector on the rear panel.

If guarding is not used, the GUARD terminal must be connected to the LO terminal. For example, when measuring a floating dc voltage -- such as the output of a floated dc amplifier -- do

not connect GUARD to the chassis ground of the amplifier; connect the GUARD terminal to the LO terminal.

Frequency Input: Front and rear panel paralleled BNC connectors labelled FREQ INPUT. Either of these connectors may receive the input signal whose frequency is to be counted when the DY-2401C is used for frequency measurement.

Frequency Standard Input/Output: Rear panel BNC connector labelled 100 KC STD OUTPUT/INPUT J3. Provides an output of the internal 100 kc time base for external use, or receives the external 100 kc time base if used. An associated toggle switch labelled INT-EXT selects the internal or external time base mode.

Counter Reset: Rear panel BNC connector labelled COUNTER RESET J4. Receives external pulse for reset of the counter section of the voltmeter.

External Programming: Rear panel MS3102A28-21S connector labelled PROGRAM CONTROL J1. Receives the external program commands when the DY-2401C is programmed by external circuit closures to ground, as in data acquisition systems. (See Section 2.3.) Also receives program commands from a DY-2410B AC/Ohms Converter or DY-2411A Guarded Data Amplifier when either of these instruments is used with the DY-2401C. (See Sections 2.2.8 and 2.2.9.)

Recording Outputs: Rear panel Amphenol 57-40500 connector, labelled BCD OUTPUT J2. Provides bcd outputs for function, data, and range, + and - bcd reference voltages, and + and - print commands. Additionally accepts holdoff signal and scan signal from recorder or coupler (scan signal is routed to PROGRAM CONTROL connector). See Section 2.4.

2.1.2 DY-2410B AC/Ohms Converter Coupling Cards

When the DY-2401C is used with a DY-2410B AC/Ohms Converter, the two coupling cards (printed circuit boards) supplied with the DY-2410B must be installed in the voltmeter. (If a DY-2410B/DY-2401C combination is purchased, the coupling cards are installed in the voltmeter at the factory.)

The two printed circuit boards are the DY-2410B Units Coupling (A9) and Ohms Delay Gate (A23). Install DY-2410B Units Coupling Card (A9) in connector XA9; AC and Ohms Delay Gate Card (A23) in connector XA23.

2.1.3 DY-2411A Guarded Data Amplifier Decimal Point Logic Card

When the DY-2401C is used with a DY-2411A Guarded Data Amplifier, the DY-2411A Decimal Point Logic Printed Circuit Card (A30) supplied with the DY-2411A must be installed in the voltmeter. This assures correct positioning of the decimal point when the DY-2411A is set for 10X gain. (If a DY-2401C/DY-2411A combination is purchased, A30 is installed in the voltmeter at the factory.) When the DY-2401C is purchased separately, a jumper board is installed in the A30 position. DY-2411A Decimal Point Logic Card A30 replaces this jumper board in receptacle XA30.

2.2 PREOPERATIONAL CHECK AND CALIBRATION

For maximum accuracy of measurements perform the following preliminary checkout and calibration procedures daily, or each time the instrument is turned on. Allow a half hour to an hour for warmup.

2.2.1 Counter Section Check

1. Set Power switch to ON, other controls as follows:

100KC STD (rear panel)	INT
FUNCTION	FREQ
ATTENUATION	CHECK
SAMPLING RATE	CW from STOP

2. Check reading at each of the three fixed sample periods in turn; readings should be as follows (±1 count):

SAMPLE PERIOD	Reading
.01 SEC	00010.0 KC
.1 SEC	0010.00 KC
1 SEC	010.000 KC

2.2.2 ZERO Adjustment (After 1/2 Hour Warmup)

1. Set Power switch to ON, note time, and set other controls as follows:

100KC STD (rear panel)	INT
FUNCTION	VOLT

RANGE	ZERO
SAMPLE PERIOD	1 SEC
SAMPLING RATE	CW from STOP

2. After the DY-2401C has been on for at least 1/2 hour, preferably an hour, short-circuit the HI, LO, and GUARD terminals and set the front panel ZERO adjustment for zero ±1 count readout on the digital display.

3. Disconnect short from HI, LO, and GUARD terminals.

2.2.3 Full-Scale Adjustment (After ZERO Adjustment)

1. Set the RANGE switch to INT+1V.

2. Set the front panel CAL+ adjustment for +1000.00 MILLIVOLTS indication on the digital readout.

3. Set the RANGE switch to INT-1V.

4. Set the front panel CAL- adjustment for -1000.00 MILLIVOLTS indication on the digital readout.

2.3 LOCAL OPERATION

Operation of the DY-2401C is straightforward and can be controlled locally at the front panel per Table 2.1 or can be programmed as required for data acquisition systems use. (See Section 2.6 for programmed operation.)

2.4 FUNCTIONS OF CONTROLS

2.4.1 Front Panel Controls

FUNCTION switch: Selects the type of measurement to be made, such as VOLT for dc voltage measurements, FREQ for frequency measurements, PERIOD for period measurements (with DY-2401C-M30), or AUTO RANGE for automatic ranging voltage measurements (with DY-2401C-M31). An EXT SEL position prepares the DY-2401C to respond to function and range programming via PROGRAM CONTROL connector J1.

RANGE switch: Selects the full-scale range of .1, 1, 10, 100, or 1000 volts. INT+1V, ZERO, and INT-1V positions are also provided for daily calibration of the instrument.

Table 2.1 Operation Summary (Std, M30, and M31 Instruments)

TURN-ON AND PRELIMINARY CONTROL SETTINGS	1. Set Power switch to ON (display digits light) 2. Set 100KC STD switch to INT (EXT if external standard is to be used) 3. Set SAMPLING RATE for desired display interval or to STOP for measurement triggering by RESET pushbutton or remote command 4. Select SAMPLE PERIOD that achieves the desired resolution of measurements (see Table 2.2)
VOLTAGE MEASUREMENT	1. Set FUNCTION switch to VOLT (VOLT or MILLIVOLT display lights) 2. Select lowest RANGE that can be used without lighting the OVERLOAD display
FREQUENCY MEASUREMENT	1. Set FUNCTION switch to FREQ (KC display lights) 2. Adjust ATTENUATION control clockwise about 30 degrees past the point where consistent measurements are obtained
PERIOD MEASUREMENT (DY-2401C-M30)	1. Set FUNCTION switch to PERIOD (MILLISEC display lights) 2. Adjust ATTENUATION control clockwise about 30 degrees past the point where consistent measurements are obtained
AUTORANGING VOLTAGE MEASUREMENT (DY-2401C-M31)	1. Set FUNCTION switch to AUTO RANGE 2. Set RANGE switch to any position except INT+1V, INT-1V, or ZERO
CONNECTIONS	1. Connect voltage to be measured and shield to HI, LO, and GUARD terminals per Figure 2.1 2. Connect signal whose frequency or period is to be measured to FREQ INPUT receptacle per Figure 2.1

SAMPLE PERIOD switch: Fixed sample periods of .01, .1, or 1 second are selected by this switch. In addition, the sample period may be started manually by switching to START position and ended by switching to STOP. An EXT SEL position allows programmed selection of a fixed sample period or programmed starting and stopping of the sample period.

SAMPLING RATE control: Adjusts the length of time that the display and recording outputs are held after the end of the sample period. The time is adjustable from 200 milliseconds to 7 seconds (approximately). When switched to STOP position, the reading is held until reset either manually or by programming. Programmed control can achieve up to 50 readings per second, as noted in Section 1.3.5.

RESET pushbutton: Resets the instrument and automatically initiates another sample period if one of the three fixed sample periods is selected and the SAMPLING RATE control is in STOP position. With SAMPLE PERIOD switch at STOP, resets the instrument to zero; sample period begins when SAMPLE PERIOD switch is set to START.

ATTENUATION control: Determines the input signal attenuation when making frequency or period measurements. In the CHECK (switched) position, a 10 kc signal derived from the internal time base oscillator is counted.

Power switch and Line fuse: Controls ac power to the voltmeter; 2 ampere fuse is used for operation from 115 volts, 1 ampere fuse for operation from 230 volts ac.

2.4.2 Rear Panel Controls

STORE/DISPLAY DURING COUNT switch: In the STORE DURING COUNT position, the previous visual display is held until the end of the new sample period, at which time the display changes directly to the new reading. In the DISPLAY DURING COUNT position, the actual counting process is displayed during the sample period.

100 KC STD INT/EXT switch: Selects the source of the counter time base reference standard. The INT position of this switch selects the internal 100 kc time base signal and connects it to

Table 2.2 Resolution of Measurements

RANGE (volts)	Full-Scale Reading	Maximum Overrange Reading	Frequency Reading	Periods Averaged*
		1 SEC SAMPLE PERIOD		
.1	100.000 mv	300.000 mv		
1.0	1000.00 mv	3000.00 mv		
10.0	10.0000 v	30.0000 v	000.000 kc	100
100.0	100.000 v	300.000 v		(1 μSec
1000.0	1000.00 v	-------		resolution)
		.1 SEC SAMPLE PERIOD		
.1	0100.00 mv	0300.00 mv		
1.0	01.0000 v	03.0000 v		
10.0	010.000 v	030.000 v	0000.00 kc	10
100.0	0100.00 v	0300.00 v		(10 μSec
1000.0	01000.0 v	-------		resolution)
		.01 SEC SAMPLE PERIOD		
.1	00100.0 mv	00300.0 mv		
1.0	001.000 v	003.000 v		
10.0	0010.00 v	0030.00 v	00000.0 kc	1
100.0	00100.0 v	00300.0 v		(100 μSec
1000.0	0010000, v	-------		resolution)

*DY-2401C-M30.

the adjacent 100 KC STD INPUT/OUTPUT BNC connector, J3. The EXT position selects an external 100 kc signal, received via BNC connector J3, as the time base standard of the instrument.

115/230V switch: Sets the instrument for operation from 115 or 230 vac (2 ampere fuse is used for 115 vac operation, 1 ampere fuse for 230 vac operation).

2.5 SPECIAL OPERATING CAPABILITIES

2.5.1 Operation With External Time Base Reference

Improved voltage, frequency, or period measurement accuracy can be achieved by using an external 100 kc reference signal with greater accuracy than the internal 100 kc reference standard of the DY-2401C. Accurate external 10 kc, 1 kc, or 100 cps references can be used to achieve multiplication of the fixed sample periods of the instrument by 10, 100, or 1,000. If such sample period multiplication is used, the decimal point must be shifted one, two, or three places to the left. Switchover to the external standard signal, which must have 2 volts peak-to-peak amplitude across a 1.2K load, is accomplished by setting the 100KC STD switch to EXT and connecting the standard signal to the 100KC STD INPUT/OUTPUT receptacle at the rear of the instrument.

2.5.2 Manual Control of Sample Period

Duration of the sample period (counter gate time) can be controlled manually, as follows:

1. Set the SAMPLE PERIOD switch to STOP and reset the counters by actuating the RESET pushbutton.

2. Set the SAMPLE PERIOD switch to START.

3. End the sample period by setting the SAMPLE PERIOD switch to STOP.

When a manually started and stopped sample period is used, flows, pressures, thrusts, countable events, etc., can be totalized over periods that are longer than the fixed periods selectable on the SAMPLE PERIOD switch. Average voltage or frequency may be determined by dividing the reading by the duration (in seconds) of the extended sample period.

2.5.3 AC Voltage Measurements and Resistance Measurements

The DY-2410B AC/Ohms Converter makes possible ac voltage and resistance measurements with the DY-2401C. Assemblies A9 and A23, supplied with the DY-2410B, must be installed in the DY-2401C.

Initial Preparation

1. Connect the DY-2410B programming cable from receptacle J8 on the rear of the DY-2410B to PROGRAM CONTROL receptacle J1 on the rear of the DY-2401C.

2. Connect the DY-2410B signal output cable from the HI, LO, and GUARD dc terminals on the terminal strip at the rear of the DY-2410B to corresponding terminals on the DY-2401C.

   NOTE

   To avoid unnecessary measurement errors, make certain that the guard shield is connected at only one point, the measurement reference point. If a GUARD terminal is tied to a LO terminal at the front panel of the DY-2410B, make certain that such connection is not duplicated between GUARD and LO terminals at the rear of the DY-2410B or at the front panel of the DY-2401C.

3. Turn on both instruments and set DY-2401C FUNCTION switch to EXT SEL, SAMPLE PERIOD switch to desired period, SAMPLING RATE control to STOP, and RANGE switch to 1V.

AC Voltage Measurement

1. Set DY-2410B FUNCTION switch to AC NORM for frequencies below 400 cps or AC FAST for frequencies above 400 cps; set DY-2410B RANGE switch to lowest range that can be used without lighting OVERLOAD indicator on DY-2401C.

2. Connect ac voltage to HI, LO, and GUARD AC/DC INPUT of DY-2410B, but do not exceed 750 volts peak input.

3. Initiate measurements by actuating the RESET pushbutton on the DY-2401C or by setting SAMPLING RATE control clockwise from STOP.

Resistance Measurement

1. Perform the DY-2410B ohms zero calibration as specified in the DY-2410B handbook.

2. Set DY-2410B FUNCTION switch to OHMS and RANGE switch to the lowest range that can be used without lighting OVERLOAD indicator on DY-2401C.

3. Connect resistance to be measured to the resistance input of the DY-2410B.

4. Initiate measurements by actuating the RESET pushbutton on the DY-2401C or by setting the SAMPLING RATE control clockwise from STOP.

2.5.4 Measurements Using the DY-2411A Guarded Data Amplifier

The DY-2411A Guarded Data Amplifier makes possible measurement of low-level inputs at a full-scale sensitivity of 10 millivolts with the DY-2401C. Assembly A30, supplied with the DY-2411A, must be installed in the DY-2401C. For maximum accuracy, the DY-2411A should be allowed a 2 hour warmup, but it can be used 15 seconds after it is turned on. Proceed as follows:

1. Connect the DY-2411A programming output cable from PROGRAM OUTPUT receptacle, J2 on the DY-2411A to the PROGRAM CONTROL receptacle, J1, on the rear of the DY-2401C.

2. Connect the DY-2411A signal output cable from OUTPUT receptacle, J5 on the DY-2411A, to the DC INPUT receptacle, J31, on the rear of the DY-2401C.

NOTE

To avoid unnecessary measurement errors, make certain that the guard shield is connected at only one point, the measurement reference point. Make certain that the guard shield is connected at the measurement source reference point and that the GUARD and LO terminals on the front panels of the DY-2411A and DY-2401C are not tied together.

3. Turn on both instruments and set the DY-2411A ZERO adjustment as specified in the DY-2411A handbook.

4. Set the DY-2401C FUNCTION switch to EXT SEL, SAMPLE PERIOD switch to desired sample period, and SAMPLING RATE control to STOP.

5. Set the DY-2411A MODE switch and DY-2401C RANGE switch as follows to achieve the lowest combined full scale range that will not produce an OVERLOAD indication on the DY-2401C display.

DY-2411A Mode	DY-2401C Range	Combined Full Scale Range
+10 Gain	.1v	10 mv
+10 Gain	1.0v	100 mv
+ 1 Gain	1.0v	1 v*

*Used for extremely high input resistance.

6. Connect the dc voltage to be measured to the HI, LO, and GUARD INPUT terminals of the DY-2411A in accordance with the general principles of Section 2.1.1 and Figure 2.1.

7. Initiate measurements by actuating the RESET pushbutton on the DY-2401C or by setting the SAMPLING RATE control clockwise from STOP.

2.6 PROGRAMMED OPERATION

The measurements described in Sections 2.3 and 2.5 may be programmed and initiated by external circuit closures to ground. This feature makes the DY-2401C particularly adaptable for use in automatic data acquisition systems. The remote control lines do not interfere with the guarding properties of the measurement circuits. All programming and input connections can be made at the rear of the instrument, which simplifies cabling.

2.6.1 Control Settings

Set front panel controls of the DY-2401C as follows for programmed operation:

FUNCTION:	EXT SEL
SAMPLE PERIOD:	EXT SEL
SAMPLING RATE:	STOP (switched position) or desired rate
RANGE:	Any position except INT -1V or +1V, ZERO

2.6.2 Programming Requirements

Refer to Table 2.3 for the pins of J1 that must be connected to program and initiate the various measurements. (An external contact closure to ground is defined as a contact closure or equivalent which raises the internal circuit to a potential that is no more negative than 1 volt at a maximum load currrent of 70 milliamperes.) Complete programming information must be present for each type of measurement, otherwise the input attenuator switches automatically to the 1000 volt range and the decimal point blanks. The programming required for each type of measurement is as follows:

<u>DC Voltage Measurements</u>
Only range and sample period must be programmed. The DY-2401C automatically measures dc voltage if the frequency measurement function is not programmed.

<u>Frequency Measurement</u>
Frequency function and sample period must be programmed.

<u>Period Measurements (DY-2401C-M30 Only)</u>
Period function and sample period (number of periods averaged) must be programmed.

<u>Autoranging Voltage Measurements (DY-2401C-M31 Only)</u>
Autoranging function and sample period must be programmed; ranges must not be programmed.

2.6.3 Application of Program Commands

The external contact closures are applied between the required pin(s) of J1 and pin Z. For example, to program a frequency measurement over a sample period of 1 second, external contact closures must connect pins B and R of J1 to pin Z.

2.6.4 Initiating Measurements

After programming commands are applied, measurement is initiated by a contact closure between pin c of J1 and pin Z, which grounds the counter reset line. An alternative method of initiating measurement is to apply a -15 volt, 25 microsecond pulse having rise time less than 2 microseconds to COUNTER RESET receptacle J4 at the rear of the DY-2401C.

2.6.5 Standard Measurement Delays

The counter reset line has a 3 millisecond delay that is in addition to the 9.7 millisecond encode delay of the DY-2401C. The additional 3 millisecond delay prevents multiple reset commands when relay contact closure is used for resetting. The 3 millisecond delay is bypassed when the instrument is reset by a pulse to J4. AC Normal, AC Fast, or resistance measurements programmed through a DY-2410B AC/Ohms Converter introduce as much as 550, 220, or 110 milliseconds additional delay.

2.6.6 Programmed Control of Extended Sample Periods

Program periods longer than 1 second as follows:

1. Enable extended sample period programming by connecting pin a of J1 to pin Z.

2. Start the sample period by connecting pin b of J1 to pin Z.

3. Stop the sample period by disconnecting pin b of J1 from pin Z.

4. Reset the DY-2401C as specified in Section 2.6.4 before initiating the next measurement.

5. Repeat steps 2, 3, and 4 of this procedure for each measurement involving an extended sample period.

6. When extended sample period programming is no longer desired, disconnect pin a of J1 from pin Z and program the correct pin for the desired fixed sample period (.01, .1, or 1 second).

NOTE

Alternatively, sample periods may be started by a relatively positive potential (-1 to +5 volts) and stopped by a negative potential (-5 to -30 volts) applied through J1 pin b across 4 KΩ.

TABLE 2.3
PROGRAM CONTROL CONNECTOR (J1)

Connector Type: MS3102A28-21S; Mating Connector: MS3106B28-21P

J1 Pin	Description		
A	Spare		
B	Volts/Frequency	Function	(Measures Volts if not Programmed)
C*	Ohms	Function	
D*	AC Normal	Function	
E*	AC Fast	Function	
F*	Spare		
G	0.1	Range (Volts)	
H	1.	Range (Volts)	
J	10.	Range (Volts)	
K	100.	Range (Volts)	
L	1000.	Range (Volts)	
M*	10MΩ		
N	.01 Sec	Sample Period	1 Periods Averaged (With Option M30)
P	.1 Sec	Sample Period	10 Periods Averaged (With Option M30)
R	1.0 Sec	Sample Period	100 Periods Averaged (With Option M30)
S	DY-2411A +10 Gain Input to A30		
T	+10 Gain to DY-2411A (With Option M31)		
U	Spare		
V	Autorange (With Option M31)		
W	Spare		
X	DY-2411A Sense (With Option M31)		
Z	Chassis Ground (System Common)		
a	Manual Gate Selection		
b	Start/Stop Manual Gate (Closure to Start)		
c	Counter Reset (Closure)		
d	Overload Reset (Pulse or Closure) Input/Output**		
e	Overload Signal Output (30 Milliamperes Maximum)		
f	Period (With Option M30)		
g, h, j, k	Spares		
m	Jumpered to J2 (49) to Route Signal Scan from Printer		
p	Holdoff Signal from Recorder, Jumpered to J2(22)		
r	Spare		
s	Chassis Ground		

* Pins for DY-2410B use only.

**Overload reset not normally used since counter resets overload circuit. When counter section is reset, pin d provides overload reset pulse for DY-2410B and DY-2411A overload reset.

2.6.7 Programming Through DY-2410B or DY-2411A

When using a DY-2410B or DY-2411A accessory instrument with the voltmeter, programming must be connected to the accessory instrument. See the applicable handbook for details. This is necessary for correct operation of the DY-2401C logic circuits, particularly the display and decimal point logic. The programming functions applied to the accessory instrument are routed through it to the DY-2401C via the same programming output cable that is to be used when making manually controlled measurements per Section 2.5.3 or 2.5.4.

2.6.8 Overload Resetting

Any overload condition occurring on a previous measurement is reset automatically by resetting the counters per Section 2.6.4. It is also possible to reset an overload condition without resetting the counters. This is accomplished by connecting pin d of J1 to pin Z temporarily.

2.7 RECORDING OUTPUTS

BCD voltages (ground referenced) are produced for each measured digit and for indication of measurement function (+VDC, -VDC, KC, etc.) and decimal point. These bcd outputs are available at the BCD OUTPUT connector, J2. Pin assignments of J2 are outlined in Table 2.4.

Also given in Table 2.4 are the bcd output weighting and levels, record command output, and bcd reference voltages. A hold command may be applied to J2 pin 22 to inhibit the voltmeter from initiating a new measurement until the recording device has completed its cycle or has stored the data. The hold should be used only when the SAMPLING RATE control is used to initiate measurements. A reset command (pulse or closure) will override the hold command and initiate a new measurement. A voltage to J2 pin 22 that is between +1 and +12 volts (maximum load 4.5 milliamperes) inhibits the counter section of the voltmeter. A voltage to J2 pin 22 that is between -1 and -35 volts enables tne counter section of the voltmeter.

The scan signal and hold command from the recording device are also routed to PROGRAM CONTROL connector J1 for systems use.

TABLE 2.4
BCD OUTPUT CONNECTOR (J2)
Connector Type: Amphenol 57-40500; Mating Connector: Amphenol 57-30500

Name	Recorder* Column	Internal Destination	4-2'-2-1 4-Line Code		J2 Pin
Decimal Multiplier 10^{-n}	1	A22- 7	A	1	1
	1	A22-10	B	2	2
	1	A22- 9	C	2'	26
	1	A22- 5	D	4	27
Counter Units	2	A11- 7	A	1	3
	2	A11- 5	B	2	4
	2	A11- H	C	2'	28
	2	A11- 4	D	4	29
Counter Tens	3	A12- 7	A	1	5
	3	A12- 5	B	2	6
	3	A12- H	C	2'	30
	3	A12- 4	D	4	31
Counter Hundreds	4	A13- 7	A	1	7
	4	A13- 5	B	2	8
	4	A13- H	C	2'	32
	4	A13- 4	D	4	33
Counter Thousands	5	A14- 7	A	1	9
	5	A14- 5	B	2	10
	5	A14- H	C	2'	34
	5	A14- 4	D	4	35
Counter Ten Thousands	6	A15- 7	A	1	11
	6	A15- 5	B	2	12
	6	A15- H	C	2'	36
	6	A15- 4	D	4	37
Counter Hundred Thousands	7	A46- 7	A	1	13
	7	A46- 5	B	2	14
	7	A46- H	C	2'	38
	7	A46- 4	D	4	39
Function	8	A22-19	A	1	15
	8	A22-20	B	2	16
	8	A22-21	C	2'	40
	8	A22-16	D	4	41
GND	Chassis	Common			50
+REF	-5 to -4v	A7 - 4			25
-REF	-24.5 to -21.5v	A7 - 6			24
+PRINT CONTROL		A17- 7			23
-PRINT CONTROL		A17-11			21
+HOLD		A18- 9			22
Scan Signal from Printer		J1 - m			49

*When used with hp J64-, J65-, or J66-562AR Digital Recorder.

TABLE 2.4
(Cont'd)

BCD OUTPUT WEIGHTING

Data	Function	Logic 4-2'-2-1	hp 562AR Printwheel Std.	4610
0	Period (With Option M30)	0 0 0 0	0	P
1	+VDC	0 0 0 1	1	+
2	-VDC	0 0 1 0	2	-
3	KC	0 0 1 1	3	F
4	KΩ (With DY-2410B)	0 1 1 0	4	K
5	MΩ (With DY-2410B)	0 1 1 1	5	M
6	Spare	1 1 0 0	6	>
7	Spare	1 1 0 1	7	<
8	Time	1 1 1 0	8	T
9	Overload	1 1 1 1	9	Q
		1 0 0 0	--- BLANK	--
	VAC (With DY-2401B)	1 0 0 1	---	A

BCD OUTPUT LEVELS

VOLTAGE LEVELS	Data:	-35 to -24v	"0"
	Function:	-35 to -24v	
	Decimal Point:	-35 to -24v	
	Data:	- 5 to - 1v	"1"
	Function:	- 5 to - 1v	
	Decimal Point:	- 5 to - 1v	
SOURCE IMPEDANCE	Data:	100K	
	Function:	33K	
	Decimal Point:	33K	
MAXIMUM CURRENT	Data:	0.3 ma	
	Function:	1.0 ma	
	Decimal Point:	1.0 ma	

TABLE 2.4
(Cont'd)

RECORD COMMAND OUTPUT

"0"*	Voltage Level:	-36 to -24v
	Source Impedance:	5000Ω
	Maximum Current:	1 ma
"1"*	Voltage Level:	-5 to -1v
	Source Impedance:	1000Ω
	Maximum Current:	15 ma

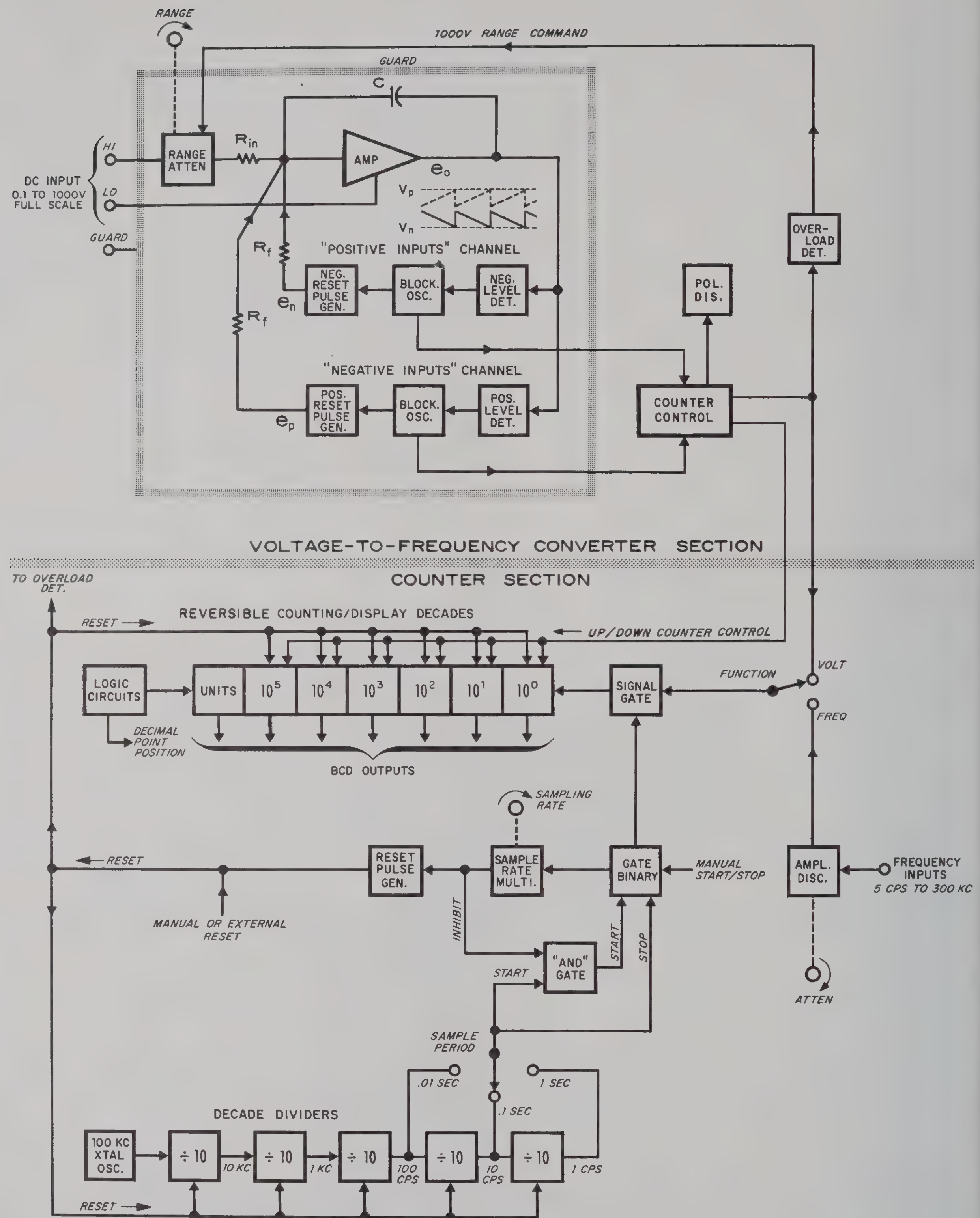
*Level 0 during sample period, 1 for record or vice-versa.

BCD REFERENCE VOLTAGES

"0"	Voltage Level:	-24.5 to -21.5
	Source Impedance:	800Ω
	Maximum Current:	1 ma
"1"	Voltage Level:	-5 to -4v
	Source Impedance:	380Ω
	Maximum Current:	0.5 ma

CONTENTS

LIST OF ILLUSTRATIONS



DY-2401C DIGITAL VOLTMETER BLOCK DIAGRAM

FIGURE 3.1

SECTION 3
THEORY OF OPERATION

3.1 GENERAL

The functional elements of the DY-2401 Integrating Digital Voltmeter are illustrated in Figure 3.1. As indicated, the DY-2401C consists principally of a voltage-to-frequency (v-f) converter and a counter. The v-f converter includes an input attenuator, integrating and pulse forming circuits, a counter control circuit, and an overload detector. The counter includes a precision time base generator, decade dividers, control logic circuits, and six reversible counting and display decades.

3.1.1 Voltage Measurement

Voltage to be measured is applied via the HI-LO input terminals to the programmable input attenuator, which provides precisely calibrated attenuations for full-scale ranges of 0.1, 1, 10, 100, and 1000 volts. The GUARD terminal is provided for connecting the v-f converter chassis to the low side of the voltage source. Thus connected, the guard shields the input to the v-f converter, blocking common-mode noise.

The output from the attenuator is transformed by the v-f converter to a proportional pulse rate. The integrating amplifier (AMP. in Figure 3.1) generates a charging current for C whose value is directly proportional to the input voltage. This current charges capacitor C to a negative or positive voltage that is inverted with respect to the voltage being measured. At a specified level, the voltage across C triggers the negative or positive inputs channel. The pulse from the triggered channel opposes the original amplifier input, discharging capacitor C. At the end of this pulse, the amplifier output current recharges capacitor C to a level that triggers one of the inputs channels. The average pulse rate thus generated is directly proportional to the average input voltage. The v-f converter output pulses are coupled through the counter control circuit and the signal gate to the counting/display decades when the FUNCTION switch is set to VOLT. The average v-f converter output rate is 100 kc for a full-scale input. Although v-f converter output pulses are generated continually while an input voltage is connected to the DY-2401C, they are counted only during sample periods.

The counter control circuit receives the pulses from the positive or negative inputs channel and provides output pulses for triggering the counting/display decades in the counter section. These pulses are also applied to an overload detector. In addition, the counter control circuit provides up/down count commands to the counting/display decades and a polarity signal that lights the + or - polarity indicator of the digital display during dc voltage measurement.

During each sample period, the counting/display decades count the pulse output from the counter control circuit when the signal gate is opened and the FUNCTION switch is set to VOLT. The decades count up during the entire sample period if the input polarity does not change. If the input polarity changes, the counter control circuit changes its count up command to a count down command. The decades then count back toward zero. If zero is reached during backward counting, the counter control circuit changes its count down command to a count up command. At the same time, the polarity display is switched. At the end of the sample period, the digital display reads out the algebraic average of the applied input voltage, tagged with the correct polarity.

The overload detector also receives a pulse train output from the counter control circuit. If the pulse rate exceeds 310 kc (310% of full scale), the overload detector turns on an OVERLOAD indication on the digital display and switches the programmable attenuator to its highest range (1000V). The overload detector is reset at the start of each new sample period.

3.1.2 Frequency Measurement

A signal whose frequency is to be measured is applied to the counter gate circuits via an amplitude discriminator. The amplitude discriminator consists of an amplifier and a Schmitt Trigger. The amplitude of the amplifier output signal is set by the front panel ATTENUATION control. The Schmitt circuit shapes the amplifier output to provide a fast-rise, constant-amplitude signal for driving the 10^0 counting/display decade. During the sample period this signal is applied to the 10^0 decade through the signal gate if the FUNCTION switch is set to FREQ.

3.1.3 Sample/Display Period Control

The sample period of the DY-2401C for voltage or frequency measurements is normally controlled by an output from the time base

dividers. However, sample period can also be controlled manually to start and stop counting at any time desired.

The time base dividers divide the 100 kc signal from the crystal-controlled reference oscillator by factors of 10. This produces accurate sample periods of 0.01, 0.1, and 1 second. The output from the divider that produces the selected sample period is coupled to an AND gate. When this signal is present and no inhibit is applied from the sample rate multivibrator, the gate binary flips. This opens the signal gate and allows voltage or frequency pulses to be counted. The inhibit from the sample rate multivibrator is removed at the end of the display interval. The duration of the inhibit is set by the SAMPLING RATE control on the front panel.

The pulses from the signal gate are counted during the selected sample period. This period is ended by a trigger from one of the decade dividers that flips the gate binary, closing the signal gate and stopping the count.

The transition of the gate binary to count inhibit state triggers the sample rate multivibrator, starting the display interval. During this interval no new count can be started. At the end of this interval the reset generator is triggered, which causes the counting/display and divider decades to be reset. Then, after a small delay that is provided to allow circuits to stabilize, a signal from the appropriate divider decade initiates a new sample period.

3.1.4 Display Units and Decimal Control

The units readout to the left of the six-digit decimal display indicates the units being measured (e.g., VOLTS or KC). This readout position is controlled via logic networks in response to control settings or programming. These logic circuits interpret the various measurement control inputs and cause the appropriate units to be indicated on the units display. The logic circuits also interpret the control settings to determine the correct position for the decimal point indication. This assures that the display will be direct reading in the units indicated.

<u>NOTE</u>

Unless otherwise stated, incomplete designations (C25, V1, Q8, etc.) which appear in the following discussions pertain to components of the circuit assembly being described.

3.2 VOLTAGE-TO-FREQUENCY CONVERTER (A28, A31-A33)

3.2.1 Programmable Attenuator (A28) (Figure 4.44)

Programmable attenuator assembly A28 standardizes the current (1 microampere full scale) that is applied to summing point P30 of integrating amplifier A31. Thus, the v-f converter output with 1000 volt input on the 1000 volt range is the same as with 100 millivolt input on the .1 volt range.

Attenuation (voltage range of the DY-2401C) is controlled by relays K1 through K5 as summarized in the RANGE switch table in Figure 4.44. These relays are controlled by the RANGE switch when the FUNCTION switch is set to VOLT, or by programming when the FUNCTION switch is set to EXT SEL position. Range control is routed through attenuator coupling logic assembly A8 (discussed in Section 3.5.1).

3.2.2 Integrating Amplifier (A31) (Figures 3.2, 4.44, and 4.46)

<u>System Operation</u>

Integrating amplifier A31 charges capacitor C25 positively or negatively at a rate that is proportional to the input current applied to its summing point, P30. This develops an output potential that is continually applied to negative and positive trigger level detectors A32 and A33. At 0.1 volt, this potential triggers one of the detectors. The polarity and which detector is triggered are determined by the polarity of the input voltage being measured. For example, negative input voltage causes a positive-going potential that triggers negative trigger level detector A32 at +0.1 volt.

The triggering of A32 or A33 produces a constant-area pulse that causes a pulsed current flow to the summing point which is greater than the input current. Amplified by A31, this current partly discharges C25. At the end of each such pulse, the input current to the amplifier again causes charging of C25 to the trigger potential. The design of the v-f converter is such that the average of the pulsed discharge currents is equal to the input current and proportional to the voltage being measured. Thus, the pulse rate is proportional to input voltage.

Integrating amplifier A31 consists of an operational amplifier with feedback coupled through C25. The gain of the operational ampli-

fier is so high (-10^7 to -10^8) that the feedback (C25) and input (R_{in}) impedances determine operation.

When a dc voltage is connected to the input of the DY-2401C, a small current, proportional to the magnitude of the input, flows through R_{in} to the amplifier. The inverted and greatly amplified output from the amplifier is fed back through C25 as an opposing current. The result is an extremely high integrating amplifier input impedance. Since the currents at the summing point very nearly cancel, the summing point voltage is virtually zero. Thus, the voltage at the amplifier output is that which is developed across C25 as it is charged by the feedback current. This voltage is directly proportional to the integral of the input current. The mathematical expression for the relationship shows that for a step input voltage (e_{in}) the amplifier output (e_o) increases linearly at a rate that is determined by the constant factors, R and C, as follows:

$$e_o = \frac{-1}{C} \int i_{in}\, dt = \frac{-1}{RC} \int e_{in}\, dt$$

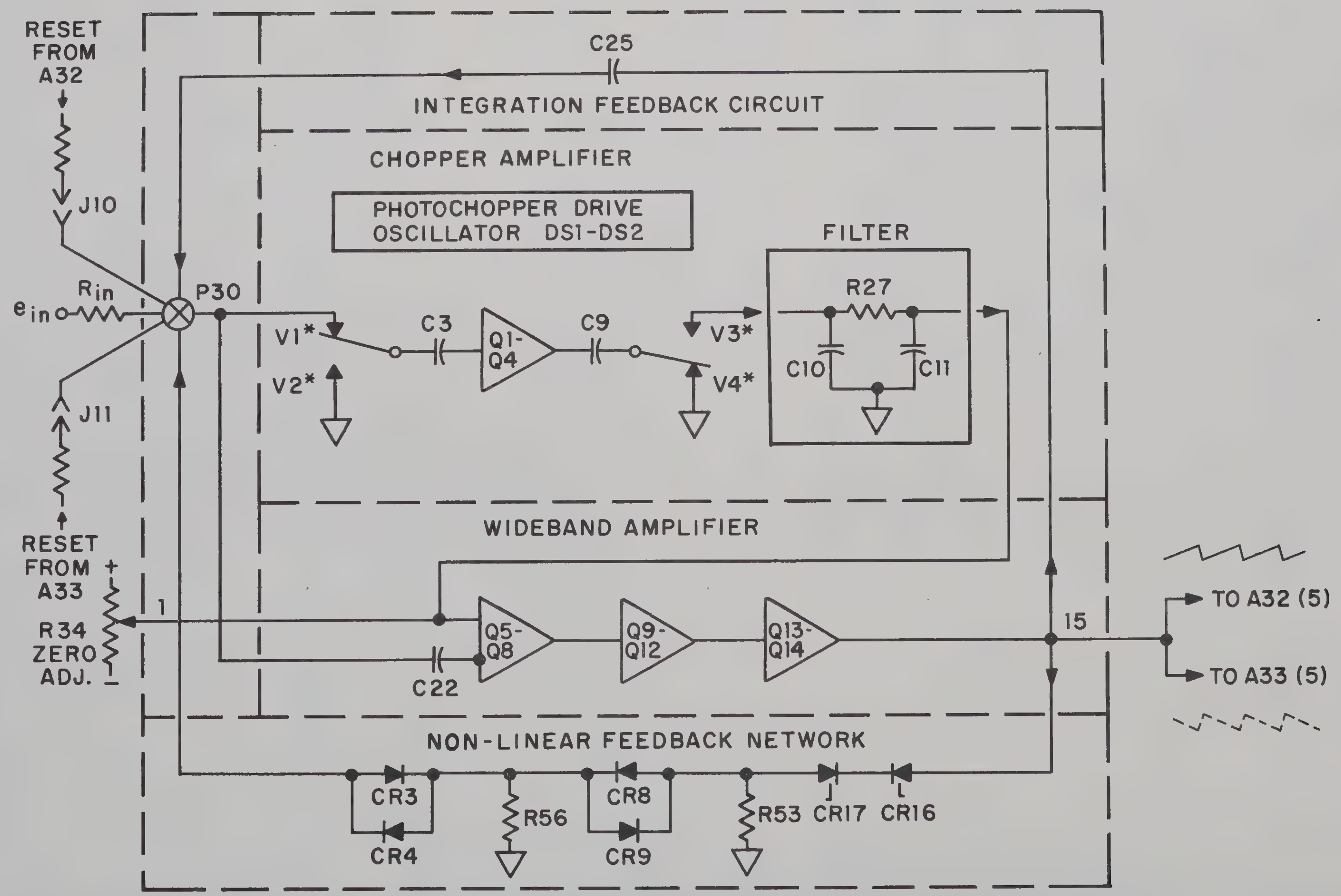
This expression is true for both the measurement input and the reset input to the summing point. The result is the balancing of input current by pulsed reset current, as discussed in the second paragraph under Section 3.2.2.

Internal Functions

The functional elements of integrating amplifier A31 are shown in Figure 3.2. These include a chopper amplifier, a wideband amplifier, the integration feedback circuit, and a non-linear feedback network. The circuit diagram is Figure 4.46.

Chopper Amplifier -- The chopper amplifier amplifies dc and low frequency signals, after their conversion to ac by a photochopper. Because only ac is amplified, the chopper amplifier introduces no dc drift into the amplifying system. Dc drift error caused by the wideband amplifier is divided by 10^4, the effective dc gain of the chopper amplifier.

The chopper amplifier input and output are modulated and demodulated synchronously by solid-state photoresistors V1-V4, which are



* MECHANICAL EQUIVALENTS OF PHOTORESISTORS V1-V4;
THE SYNCHRONIZATION INVERTS THE OUTPUT SIGNAL

Figure 3.2 Integrating Operational Amplifier A31, Functional Diagram

driven by flashes of light from the neon bulbs of a relaxation oscillator. The photochopper mechanical equivalent is shown in Figure 3.2. After filtering, the pulsed signal from demodulating photochoppers V3 and V4 is a smooth, amplified and inverted replica of the dc and low frequency components of the signal at the summing point. This output is applied to one input of the wideband amplifier. The chopper amplifier output is prevented from exceeding ±0.5 volts by CR6 and CR7.

Wideband Amplifier -- The wideband amplifier amplifies dc and low frequency signal components from the chopper amplifier and high frequency signal components coupled through C22. The high frequency signal components are connected to the inverting input of differential input stage Q5-Q8. The output from Q8 is amplified without further inversion by Q9-Q12. Complementary push-pull emitter followers Q13 and Q14 form a low-impedance, single ended output stage that has practically equal output impedance for either output polarity. The output current charges C25 to the trigger level of A32 or A33.

Gain and response of the wideband amplifier are shaped by negative feedback from Q10 to Q9 and from Q13-Q14 to Q11. A filter network in the Q9 base circuit completes the shaping of response. Overall, the wideband amplifier amplifies input signals from dc to about 1 megacycle, with a 6 db/octave rolloff of signal gain at frequencies above 100 cps.

Potentiometer R34, the front panel ZERO adjustment, is set to make zero input current produce zero output current from the integrating amplifier. It cancels fixed dc offset voltages existing within the integrating amplifier by applying a stable equivalent voltage of opposite polarity to the wideband amplifier dc input (the base of Q5).

Non-Linear Feedback Network -- Protection of the amplifier from severe short-term overloading is provided by a non-linear feedback network whose principal elements are voltage breakdown diodes CR-16 and CR17. Whenever the amplifier output voltage exceeds the breakdown potential of CR16 or CR17, these diodes conduct a negative feedback current that prevents saturation of the amplifier, which could cause excessive recovery time.

3.2.3 Trigger Level Detectors (A32 and A33) (Figure 4.44)

A32 and A33 are voltage level sensitive pulse generators. These detectors are essentially identical, except that one responds to negative voltage and the other to positive voltage. Either of these pulse generators provides a constant voltage-time area pulse of a polarity opposite to the polarity of the input signal.

Operation of detector A33 is typical. When a positive voltage is being measured, the potential from the output of A31 increases negatively until it reaches the -0.1 volt trigger level of A33. The trigger level is set by potentiometer R27. At the trigger level, blocking oscillator Q3 is triggered through emitter follower Q6, non-inverting amplifier Q5, and emitter follower Q4. The output from Q3 is a sharp pulse that triggers binary Q1-Q2. This pulse is also transformer-coupled through the guard shield to the counter control circuit on A16.

The pulse from the blocking oscillator triggers a change of binary state, causing reversal of current in the primary of a special saturating-core transformer, T1. This produces a pulse in the secon ary, which is connected for full-wave rectification. Because of the precisely-controlled saturation characteristics of the T1 core, the output pulse has constant volt-time area. The output pulse is applied to summing point P30 through a resistor network, Through integrating amplifier A31 this resets the potential across C25 to a level that is below the trigger level.

If the input voltage is still present, the amplifier output continues to move toward the trigger level. Each time the trigger level is reached another reset pulse is generated, tending to keep the amplifier output constant near the trigger level, as shown in Figure 3.3

Over any given interval the sum of the areas of the reset pulses is equal to the total integral of the input signal. By counting the number of such pulses generated during the sample period a direct measurement of the average input voltage is obtained. For exampl if each reset pulse has an area of 10 microvolt-seconds (i.e., 10

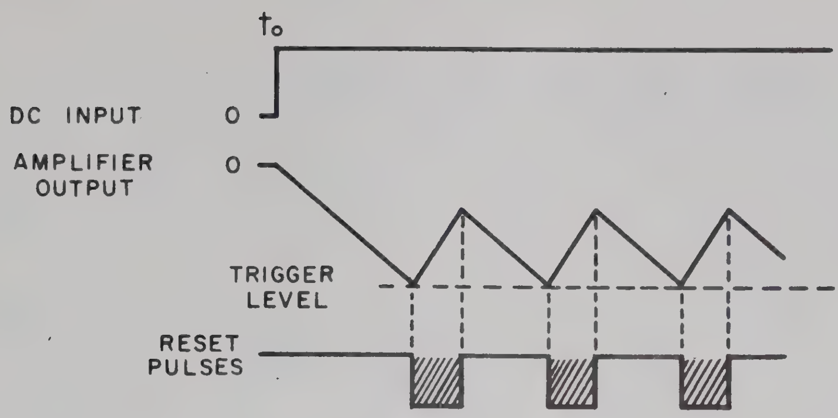


Figure 3.3 V-F Converter Waveforms

volt amplitude and 1 microsecond duration), one volt at the input will produce 100,000 output pulses per second (100,000 x 10 microvolt-seconds = 1 volt-second).

3.3 COUNTER CONTROL (A16) (Figures 4.10A, 4.10B, and 4.26)

The positive and negative pulse train outputs from the v-f converter are transformer coupled via T5 or T4 through the guard shield to the counter control circuits on A16. When a positive input voltage is being measured by the voltmeter the pulses are coupled through pin A to amplifier-inverter Q1. When a negative input voltage is being measured the pulses are coupled through pin B to Q2. The polarity of the input pulses is negative from either T5 or T4 of the v-f converter.

3.3.1 Initial Count Up Phase

When the first pulse during a sample period is from the positive channel, the output from Q1 triggers input polarity binary Q3-Q4 to positive state (Q3 off, Q4 conducting, collector positive). (See timing diagram in Figure 4.26.) When the decade binaries are all in zero state (as after resetting), the detection of zero and the state of Q3-Q4 sets count polarity binary Q7-Q8 to the identical state. For example, Q3 off and Q4 on sets Q8 on and Q7 off, which is the positive state of the count polarity binary. When both binaries are in identical states, the output from the count polarity AND gates enables the count $\overline{\text{up}}$ command to the counters. This places the count $\overline{\text{up}}$ line from pin V near negative 35 volts and the count $\overline{\text{down}}$ line from pin 18 near ground, causing the decades to count up.

The positive state (Q7 off, Q8 on) or the negative state (Q8 off, Q7 on) of the count polarity binary is coupled through amplifier Q6 or Q5 to the + and - lamp and signal lines (pins 7, H, 8, and J). Conduction through Q6 sets the + lines "true", and conduction through Q5 sets the - lines "true". The "true" condition lights the lamp and activates the signal line to which it is applied. The polarity indication is inhibited by cutoff of polarity blanking amplifier Q24 when the FREQ, AC, or OHMS measurement function is selected, clamping pin P of A16 to ground.

3.3.2 Response to Reversal of Input Voltage Polarity

Whenever the voltage input to the voltmeter reverses polarity, the first pulse from the other channel triggers a reversal of Q3-Q4 states. For example, if initial input polarity was positive, the first negative channel pulse cuts off **Q4 via input amplifie** **Q2,** turning on Q3. Because zero is not being detected, the count polarity binary input AND gates are closed to this state change and binaries Q3-Q4 and Q7-Q8 are now in different states. Q3-Q4 is negative and Q7-Q8 is positive. This triggering enables the count down command to the counters. The count $\overline{\text{down}}$ line is near negative 35 volts, the count $\overline{\text{up}}$ line is near ground, and the decades now count backward.

3.3.3 Response to Zero Count

As the decades reach the count of zero, the detection of zero opens the count polarity binary input AND gates, setting the count polarity binary to the same state as the input polarity binary. This reverses the signals applied to the + and - lamp and signal lines and enables the count up command. The decades now accumulate a forward count whose polarity is identified correctly.

3.3.4 Overload Output

OR gate CR15-CR33 provides a path for applying positive pulses from Q1 or Q2 to overload detector A10 through pin 1.

3.3.5 Counter Output

OR gate CR26-CR27 provides a path for triggering one-shot Q18-Q19 with positive pulses from Q1 or Q2. Each positive pulse from the OR gate cuts off Q18, reversing the quiescent state of the one-

shot circuit. The negative pulse from the collector of Q18 is coupled through pin 2, logic assembly A19, and a differentiating circuit to 10^0 counting/display decade A11. The differentiated, positive-going trailing edge of the Q18 output pulse triggers decade A11 after 1.5 microseconds delay.

Whenever zero is detected or input polarity changes, the delay of the counter trigger is extended to assure triggering after all counter control logic changes have occurred and settled. Delay is extended by reducing the turn-on bias that is applied to the base of Q18, which increases Q18 off time. When the Q22 and Q18 collectors are both negative, Q25 is turned on through a resistance-capacitance (r-c) delay circuit. Conduction through Q25 reduces the bias voltage that is applied to the base of Q18. As determined by the r-c delay, conduction through Q25 decreases exponentially at a rate that permits Q18 to turn on after it has been cut off for about 6 microseconds. Similar r-c circuits turn on A17 when input polarity binary Q3-Q4 changes states. The conduction through Q17 timed by these r-c circuits extends Q18 off time to about 9 microseconds.

3.3.6 Zero Detect Logic

During display periods, the zero detect logic is disabled by a ground input from A17Q8 to pin F, which closes the zero detect AND gate. During the sample period this inhibit is removed, opening the gate to the "negative true" zero detect input from counting/display decades A11-A15 and A46. The input from these decades is negative only when all binaries are in the zero state. The "negative true" zero detect input is coupled through Q22 to the count polarity input AND gates and the 6 microsecond delay AND gate. The disabling of the zero detect output from Q22 prevents the count polarity binary from changing states until the next measurement period.

3.4 OVERLOAD DETECTOR (A10) (Figures 4.10A and 4.22)

The pulse train output from the v-f converter is coupled through counter control assembly A16 to overload detector A10, pin 1. When the pulse rate exceeds 310 kc (310% of full scale), an overload signal is generated causing:

1. an OVERLOAD indication on units indicator display A24;
2. input attenuator switchover to 1000 volt range (by energizing relay K5);

3. de-energizing of previously energized range programming relays; and

4. an overload signal on J1 (e) for external use and to printer coupling card A22 for recording.

3.4.1 Overload Signal Memory

The overload signal memory is 4-layer diode CR6, which is turned on by a positive-going pulse coupled to its anode from the collector of Q1. Once it is turned on, CR6 continues conducting, clamping the overload logic line to ground (true) until its holding current is interrupted. CR6 is cut off and the overload indication is reset when a positive pulse is applied to the CR6 cathode through C7 and R13. The positive pulse is produced by grounding J1 (d) through an external contact closure. The negative-going reset pulse which turns on Q2, produces the same effect as grounding J1 (d). The reset pulse is generated by assembly A18 or A7 as described in Sections 3.6.4 and 3.17.1.

3.4.2 Overload Detection

The positive overload memory trigger pulse from the collector of Q1 is developed when current flows through the No. 2 winding of transformer T1. If the v-f converter is not overloaded, current flows only through the No. 1 winding of T1. The conditions which determine when the current switches from winding No. 1 to winding No. 2 are the voltage levels existing at the cathodes of CR3 and CR4. The voltage at the cathode of CR4 is set to about -25 volts by potentiometer R2. The voltage at the cathode of CR3 is determined by the frequency of the pulses arriving at pin 1. These pulses, coupled through C1 and CR2, apply a positive charge across C10. Between pulses C10 charges negatively. The voltage across C10 depends upon the pulse frequency. Below a pulse frequency of 310 kc the voltage across C10 is such that the cathode of CR3 is more negative than the cathode of CR4 and current flows from ground, through R5, and winding No. 1. Thermal noise voltages developed across R5 as a result of the current flow are coupled to amplifier Q1. The output of amplifier Q1 is transformer coupled back to winding No. 1. Because of the phase relation between the primary and secondary winding No. 1, the feedback voltage is out of phase with the input, resulting in cancellation of the noise voltage.

When the input pulse frequency reaches 310 kc, the voltage across C10 reaches a level where the cathode of CR3 becomes more posi-

tive than the cathode of CR4. At this point the current switches from winding No. 1 to winding No. 2. The thermal noise voltage developed across R5 is now amplified and inverted by Q1 and coupled back to winding No. 2. The feedback from the primary to secondary winding No. 2 is in phase with the amplifier input. Regeneration quickly saturates the amplifier, generating a positive pulse large enough to trigger conduction of 4-layer diode CR6. The regenerative action also increases current to the point where the transformer core saturates and no longer provides the coupling action. This stops the regenerative action. Amplifier conduction then decreases, returning to the previous unsaturated condition. After a time delay that is essentially determined by the time constant of R5 and C2, the comparison circuit is ready to cycle again. This action continues as long as the overload, producing a train of positive-going pulses from the collector of Q1. Although only one pulse is required to turn on the 4-layer diode, the series of pulses prevents removal of the overload indication by resetting until the overload condition has been corrected. Usually only a few pulses are generated before the attenuator is switched to the 1000 volt range.

3.5 ATTENUATOR COUPLING LOGIC (A8) AND 1V RELAY TIMING (A47)

3.5.1 Attenuator Coupling Logic (A8) (Figure 4.18)

The attenuator coupling logic controls range programming relays K1 through K5 of attenuator assembly A28. During normal manual operation, the RANGE switch provides a ground connection through the FUNCTION switch to the input logic line for the desired range. During external programming, the ground connection must be provided at the correct pin of PROGRAM CONNECTOR J1, from which it is routed through the FUNCTION switch to the input logic line. For example, a ground connection to pin 12 of A8 programs the 100 volt range. Coupled through diode CR5, this causes transistor Q8 to conduct, energizing 100 volt range relay K4, provided that no overload condition exists and that no ac or ohms measurement using a DY-2410B is being made. This example is typical of operation of the other range programming lines, except for the 0.1 volt range. When the 0.1 volt range is selected, relays K1 and K2 are both energized.

The detection of an overload by the circuit on A10 causes pins 2 and 13 of A8 to be gounded. The grounding of pin 13 energizes 1000 volt range relay K5. The grounding of pin 2, amplified by

Q3 and Q4 and connected through diodes to the bases of gating transistors Q5, 6, 7, and 8, cuts off current to range programming relays K1 through K4, causing them to de-energize.

When a DY-2410B is used with the DY-2401C for ac or ohms measurements, a ground is connected to pin 4 of A8 from the DY-2410B units coupling card, A9. This signal is used to turn on Q6, energizing the 1 volt range relay, K2. Amplified by Q1 and Q2, this signal disables the other range gating transistors.

3.5.2 1 Volt Relay Timing (A47) (Figures 4.18 and 4.44)

The 1 volt relay timing circuit on A47 times the energizing and de-energizing of 1 volt range relay K2 so that it and 1000 volt range relay K5 are never energized at the same time. If K2 and K5 were energized at the same time, up to 1000 volts could be applied across attenuator resistor R42. For a brief period R42 would dissipate 100 watts, sustaining damage proportional to the duration of the overload.

When K2 is not programmed, conduction through Q1 discharges capacitor C2. When K2 is programmed, C2 initially presents a low impedance path while it charges. The long time constant charging of C2 holds K2 de-energized until all other relays, including K5, have had time to de-energize.

When the attenuator is switched from 1V to 1000V range, programming of relay K2 is interrupted. The energy stored in the coil of K2 discharges across capacitor C1 and resistor R1 and relay K2 de-energizes. The energizing of K5 is delayed by capacitor C102 until K2 has de-energized. C102 is connected across the K5 coil. At the same time, capacitor C2 of A47 is disconnected from the K2 relay coil by the reversal of voltage polarities across diode CR1. It is discharged by Q1 and thus has no effect upon de-energize timing of K2.

3.6 GATE CONTROL (A17) AND DISPLAY CONTROL (A18) (Figures 4.10A and 4.28)

Gate and display control assemblies A17 and A18 operate together to control the gating of voltage or frequency measurement pulses

to input counter decade A11. They also control the display period and the transfer of each new measurement to the digital displays of the decade counters. These functions are performed as directed by the settings of the SAMPLE PERIOD switch and the SAMPLING RATE control.

3.6.1 Measurement Phase

The measurement/display cycle of the DY-2401C is illustrated in Figure 4.28. The measurement phase of this cycle begins when the decade divider output selected by the SAMPLE PERIOD switch is applied to start/stop input pin 4 of gate control assembly A17 via logic assembly A21. The positive-going part of the decade divider signal cuts off A17Q1 of gate flip-flop A17Q1-Q2. This opens a clamp to -1 volt that normally inhibits triggering of the first decade counter, A11. The next positive-going excursion of the time base input signal cuts off A17Q2, turning on A17Q1, blanking counter input triggers applied to A11 pin 10, and terminating the measurement.

3.6.2 Transfer to Digital Display

The positive-going voltage from the A17Q1 collector at the end of the measurement period cuts off A18Q2 of transfer one-shot A18Q1-Q2. The one-shot remains in this unstable state (A18Q2 off, A18Q1 on) for about 70 milliseconds. During this period, storage gate amplifier A18Q3 is cut off, allowing the count stored by the decade counter binaries to be transferred to the display storage circuits. At the end of this period conduction through A18Q2 turns on storage gate amplifier A18Q3, which holds the new count until the next transfer pulse is triggered.

The previously-described transfer mechanism is effective only when STORE/DISPLAY switch S7 is in STORE position. When S7 is in DISPLAY position the states of the decade counter binaries are displayed at all times, not just after transfer.

3.6.3 Variable Duration Display Phase

The negative transfer pulse from the A18Q2 collector turns on A18-Q4, cutting off A18Q5 of the display timing flip-flop. (Flip-flop A18Q4-Q5 is actually a one-shot whenever the SAMPLING RATE control is not switched to STOP position.) Duration of this unstable state, determined by the time constant of A18C8 and the

setting of SAMPLING RATE potentiometer R204, may range from 0.2 to 7 seconds. Conduction through A18Q4 inhibits start AND gate A17C1-R3 of gate flip-flop A17Q1-Q2, by cutting off A18CR7 and A17Q4. This prevents the start of a measurement during the display period.

An external clamp to ground from a digital recorder, programmer, or other digital data processing device may be applied to J1 (p) or J2 (22) to hold the display and recording outputs longer than the normal period. This clamp, coupled through A17CR9 to pin 10 of A18, holds A18Q5 off until it is removed.

3.6.4 Resetting

The negative-going trailing edge of the signal from the A18Q4 collector triggers a negative reset pulse via amplifiers A18Q6-Q7. This negative pulse resets decade dividers A1-A5, decade counters A11-A15 and A46, gate flip-flop A17Q1-Q2, and the overload signal memory on overload detector A10. After resetting, the measurement phase can be initiated as described in Section 3.6.1.

Current generator A17Q7 conducts additional bias to A17Q5 during the period between resetting and the start triggering of gate flip-flop A17Q1-Q2. This assures that A18Q4-Q5 remains in the stable "measurement enable" state until it is triggered to initiate the display period.

3.6.5 Manual Control of Measurement Phase

During manual operation, the automatic measurement/display control logic is bypassed. The starting and stopping of the measurement is controlled by the START and STOP positions of the SAMPLE PERIOD switch. The START and STOP positions both apply a clamp via the manual logic line and pin 10 that holds A18Q5 cut off, inhibiting triggering by the time base input from A21, pin 24. The positive START level cuts off A17Q1, starting the measurement. A negative level produced by switching to STOP position turns on A17Q1, stopping the measurement.

3.6.6 Reset-Triggered Measurement and Display

Switching the SAMPLING RATE control to STOP position converts A18Q4-Q5 to a flip-flop. The measurement-display cycle is then triggered by a positive-going reset pulse from the -35 volt regu-

lator and reset card, A7. This pulse cuts off A18Q4, which turns on A18Q5, enabling the start triggering of gate flip-flop A17Q1-Q2 as described in Section 3.6.1. Transfer one-shot A18Q1-Q2 and display timing flip-flop A18Q4-Q5 are triggered as noted in Sections 3.6.2 and 3.6.3, except that A18Q4-Q5 continues to inhibit measurement until it is reset by a positive-going pulse from A7.

3.6.7 Record Signal Emitter Followers

Record signal emitter followers A17Q5 and A17Q6 couple the state of gate flip-flop A17Q1-Q2 to the digital recorder or other digital data processing device that may be connected to the BCD output of the DY-2401C. During measurement A17Q5 clamps the -record command line to ground (positive true). A17Q6 clamps the +record command line to ground during the display period, when the BCD outputs of the DY-2401C are not changing.

3.7 100 KC OSCILLATOR AND SCHMITT TRIGGER (A6) (Figures 4.10A and 4.14)

The internal time base standard for the counter section is generated by a 100 kc crystal controlled oscillator. The output of the oscillator is routed to the 100 KC STD switch, S6. The INT position of S6 connects the 100 kc oscillator output to a Schmitt trigger circuit. The output of the Schmitt trigger is a 100 kc square wave that is used to trigger the first decade divider (A1). A rear-panel BNC connector, OUTPUT/INPUT, is connected via the INT/EXT switch to the output of the Schmitt trigger so that the internally generated 100 kc signal can be used externally. The EXT position of S6 connects OUTPUT/INPUT receptacle J3 to the Schmitt trigger input. The Schmitt circuit may then be triggered by an external time base signal connected to J3.

3.8 TIME BASE DIVIDERS (A1-A5) (Figures 4.10A and 4.12)

There are five identical time base dividers operating in series to successively divide the 100 kc time base frequency by ten to provide output frequencies of 10 kc, 1 kc, 100 cps, 10 cps, and 1 cps. The 10 kc output is the standard frequency that is used to check the operation of the counter section. The 100 cps, 10 cps, and 1 cps outputs are used for the standard sample periods of 0.01 second, 0.1 second, and 1 second.

Each decade divider consists of four cascaded transistorized binaries, such that the output of the first is coupled to the input of the second, and so on. Feedback networks are arranged on the binaries to provide 4-2'-2-1 binary code weighting and input-to-output division ratio of 10:1.

At the end of each counter display period the decade dividers are reset. During normal operation, when the sampling rate is determined by variable setting of the SAMPLING RATE control (i.e. 0.2 to 7 seconds), the reset pulse from the display control circuit (A18 resets the decade dividers (A1-A5) to 97033. This means that 2967 counts (or 29.67 milliseconds) are required before the outputs of th decade dividers can start another sample period. This delay allows A18C8 (the capacitor determining the 0.2 to 7 seconds display time) to discharge before the next display period starts. In the fast sampling mode of operation, when the SAMPLING RATE control is in the STOP position and resetting from A7 is used, the decade dividers are reset to 99033. This means that 967 counts (or 9.67 milliseconds) are required before the next count can start. This small delay provides attenuator switching time and settling time for the D 2411A Guarded Data Amplifier, if used.

3.9 SENSITIVITY CONTROL, INPUT AMPLIFIER, AND TRIGGER CIRCUIT (A25-A27) (Figures 4.10A and 4.42)

When the DY-2401C is used for making direct frequency measurements, the input frequency is connected to the front or rear panel FREQ INPUT connector. It is then routed through the attenuation control circuit where the level of the input signal is adjusted by the ATTENUATION control to provide a reliable count. When the ATTENUATION control is in the CHECK position, the 10 kc frequency from the first decade divider, A1, is routed through the attenuation control circuit to be counted. The output of the attenuation control circuit is coupled through the input amplifier to the trigger circuit. The trigger circuit is a Schmitt trigger that provides a fast-rise, constant-amplitude output square wave which is routed through the counter logic on A19 to decade counter A11.

3.10 REVERSIBLE 300 KC DECADE COUNTERS (A11-A15, A46) (Figures 4.10A and 4.24)

Six identical reversible decade counting units connected in series count input pulses and display the count as a six-digit number.

The positive input triggers are coupled to the first counting decade, A11, through logic on A19 and a differentiating network. Gating of the triggers is controlled by A17 as described in Section 3.6.1.

3.10.1 Counting

The counting decades can count either forward or backward. The count direction is determined by the states of the count $\overline{\text{up}}$ and count $\overline{\text{down}}$ control lines from counter control assembly, A16. Regardless of count direction, the feedback between the binaries is arranged to produce a count output in 4-2'-2-1 Binary-Coded-Decimal (BCD) form. The BCD outputs from the decades are connected to the rear panel BCD OUTPUT receptacle, J2.

Forward Counting

The decades always count forward during frequency measurements and during the first phase of voltage measurements. Forward counting is enabled when the count $\overline{\text{down}}$ line is clamped to ground and the count $\overline{\text{up}}$ line is placed near negative 35 volts by the counter control logic on A16. This closes the backward count AND gates and opens the forward count AND gates. Positive triggers are coupled from the collectors of odd-numbered transistors (Q1, Q3, Q5, Q7) to succeeding stages. Each trigger advances the count by one. After the count reaches 9 and is then advanced to zero, the first decade generates a trigger which advances the count of the second decade, and so on through all six counting units. The waveforms associated with forward counting are shown at the left of the dashed line in the Figure 4.24 waveforms diagram. The count progression is as follows:

Count	Even-Numbered Transistors On	BCD Output Table
0	NONE	0
1	Q2	1
2	Q4	2
3	Q2, Q4	1 + 2
4	Q4, Q8	2 + 2
5	Q2, Q4, Q8	1 + 2 + 2'
6	Q8, Q6	2' + 4
7	Q2, Q8, Q6	1 + 2' + 4
8	Q4, Q8, Q6	2 + 2' + 4
9	Q2, Q4, Q8, Q6	1 + 2 + 2' + 4
10	NONE	0 + a trigger to the next decade

Backward Counting
The decades are commanded by the counter control logic to count backward when the polarity of the input voltage reverses. The backward count continues until a zero count is detected. Backward counting is enabled when the count $\overline{\text{up}}$ line is clamped to ground and the count $\overline{\text{down}}$ line is placed near negative 35 volts by the counter control logic on A16. This opens the backward count AND gates and closes the forward count AND gates. Positive triggers are coupled from the collectors of even-numbered transistors (Q2, Q4, Q6, Q8) to succeeding stages. If the forward count accumulated before reversal of the count commands is 10, it consists of zero states in the A11 decade, a 1 state in the A12 decade, and zero states in the remaining decades. The first reverse count trigger sets the A11 decade to the count of 9, which triggers the A12 decade to zero. The progression of the backward count is the exact reverse of the forward count progression.

3.10.2 Zero Detection

Decade counting units A11-A15 and A46 contain an 18-input AND gate* whose output is a positive-true inhibit if any of the decade binaries are in other than a zero state. All binaries in a decade are in zero state when the odd-numbered transistors (Q1, Q3, Q5, Q7) are conducting. When all binaries in the counting decades are in zero state, the zero detect line is no longer clamped to ground by conduction through an even-numbered transistor (Q2, Q4, Q8) in any of the decades. During a measurement period, removal of the clamp activates the zero detect logic of A16. In response to the detection of zero, the counter control logic commands forward counting by the decades.

3.10.3 Display Section

The 4-2'-2-1 BCD output from the decade binaries is connected to neon lamps associated with a photoconductive translator matrix The pattern of lighted neon lamps sets up a low-resistance path through the translator matrix that causes the correct numeral to light in the Nixie digital display tube. For example, a 5 count lights neon lamps DS1A, DS2A, DS3B, and DS4A. When decoded by the matrix, the lighted states of DS1A, DS3B, and DS4A light the 5 numeral in the Nixie tube.

*CR9, 10, and 13 of each decade.

The position of STORE/DISPLAY switch S7 determines when each count is displayed. The DISPLAY position of S7 disconnects the store signal from the neon transfer line. This is used for continuous display of the binary states before, during, and after each count. The STORE position of S7 connects the store signal (a relatively low-impedance ground return) to the neon transfer line. The store signal is interrupted at the end of each count by a 70 millisecond transfer pulse that is generated on display control assembly A18. This interruption connects the binaries to the neon lamps. Restoration of the store signal at the end of the transfer pulse keeps the neon lamps on and off in the configuration established during the transfer pulse by providing a return path that is independent of the binaries.

3.10.4 Resetting and Presetting

Reversible decade counters A11-A15 and A46 are reset by a negative pulse applied to pin R. This reset pulse turns on all odd-numbered transistors (Q1, Q3, Q5, Q7), establishing the zero state.

Presetting is used for special data system applications. It involves applying a negative pulse to pins L, 6, F, and E of the various decades as required to achieve the desired initial count states. The negative preset pulse turns on the transistors (Q2, Q4, Q6, Q8) to which it is applied.

3.11 UNITS/COUNTER INPUT LOGIC (A19) (Figures 4.10A, 4.10C, and 4.30)

The units logic of A19 connects to the front-panel FUNCTION and SAMPLE PERIOD switches and provides signal outputs for lighting the units display, for decimal point logic assembly A20 and for blanking/time base selection assembly A21. The units logic is illustrated in Figures 4.10C and 4.30.

By means of positive AND gates the counter input logic determines whether the counter gate is controlled manually or by one of the standard sample periods. When voltage is to be measured, the $\overline{\text{volt}}$ signal at pin 15 of A19 is negative. This signal opens AND gate Q10 to the negative pulses that are received from the voltage-to-frequency converter via counter control assembly A16. These pulses are coupled through AND gate Q10 to units decade counter A11 through a trigger differentiating circuit. The positive triggers produced by this circuit are counted when the counter gate opens.

When the frequency of a signal is to be counted, the $\overline{\text{freq}}$ signal at pin 17 is negative. This signal opens AND gate Q11 to the positive pulses from the Schmitt trigger on A27. The output pulses from Q11 are routed to units decade counter A11 in the same manner as voltage pulses.

When opening and closing of the counter gate (flip-flop A17Q1-Q2) is manually controlled (SAMPLE PERIOD switch in START or STOP position), the $\overline{\text{man}}$ logic line is negative. This opens AND gate Q12 to the logic level on the start-stop logic line. When the SAMPLE PERIOD switch is set to START, the ground clamp output from Q12 sets A17Q1-Q2 to measurement enable state. When the SAMPLE PERIOD switch is set to STOP position, the negative-going voltage passed by the base-collector diode of Q12 turns on A17Q1, setting A17Q1-Q2 to measurement inhibit state.

3.12 DECIMAL POINT LOGIC ASSEMBLIES (A20 and A30)

3.12.1 Decimal Point Logic Assembly (A20) (Figures 4.10C, 4.32, and 4.51)

The decimal point lamps are controlled via a photoconductor assembly. (See Figure 4.51.) When a given decimal lamp is to light, the appropriate neon lamp (NE-1 to NE-5) in the photoconductor assembly is lighted by the decimal point logic circuits on A20. The light from the neon lamp reduces the resistance in the associated photoconductor, allowing the proper decimal lamp in the decimal assembly to light. When an incomplete measurement program occurs, a signal from the blanking logic circuit on A21 lights NE-6, which prevents any of the other decimal lamp controlling neons (NE-1 to NE-5) from lighting. This in turn prevents lighting of any of the decimal points on the visual display.

The decimal point logic circuitry, consisting of diode and transistor gates, translates the control settings for the various modes of operation to determine the proper decimal point position. This assures that the digital display is direct reading in volts, millivolts, or kilocycles. This logic also provides the correct decimal point placement for ac voltage measurements and resistance measurements when a DY-2410B is used with the DY-2401C.

The decimal point logic is illustrated in Figure 4.10C. Essentially, the diode and transistor gates combine negative- and posi-

tive-true inputs to light one of the five neon lamps (NE1-NE5) in the photoconductor assembly. The positive-true input, a voltage range (0.1, 1, 10, 100, or 1000) for voltage measurements, completes an emitter ground for one or more of the transistor gates. A negative true input applied to the base of one of these transistor gates then produces a positive true collector output that lights the associated neon lamp. The negative true transistor AND gate input is assembled by a diode AND gate; it represents the removal of all positive true inputs, which are clamps to ground.

Decimal point placement is determined by the function measured (VOLT or FREQ), the voltage range (if VOLT function is selected), and the sample period. For example, when FREQ function is selected, transistor AND gates Q5, Q7, or Q9 are enabled via OR gate CR14-CR15. Selection of sample period determines which transistor AND gate opens and which neon lamp lights, as follows:

Sample Period	Transistor Gate Opened	Neon Lamp Lighted	Decimal Placement on Digital Display
.01 SEC	Q5	NE2	00000.0
0.1 SEC	Q7	NE3	0000.00
1 SEC	Q9	NE4	000.000

Only one neon lamp line can be positive at any one time; all other lines are negative. If none of the lines is positive, the output of negative AND gate CR24-CR28 is negative, indicating an incomplete program. This negative signal is coupled to logic on A21, causing the decimal point display to blank and the 1000V attenuator relay to energize.

3.12.2 DY-2411A Decimal Point Logic Card (A30) (Figure 4.48)

Logic card A30 provides for correct positioning of the decimal point when the DY-2401C is used with a DY-2411A Guarded Data Amplifier. The logic shifts the decimal one place to the left, or two places to the right while lighting the MILLI portion of the MILLIVOLTS display, when the DY-2411A is set for +10 gain.

As an example of the A30 logic, assume that the DY-2401C is programmed for 1V RANGE and .01 SEC SAMPLE PERIOD. This grounds the emitters of AND gates Q9, Q10, and Q11 via the NE4 logic line and A20. When the DY-2411A is set for +1 gain, the false state (near -35 volts) of the X10 logic line turns on

Q1, grounding the $\overline{\text{X10}}$ logic line and closing AND gates Q9 and Q11. AND gate Q10 is opened, lighting NE4 on the photoconductor assembly. When the DY-2411A is set for +10 gain, Q1 is cut off and Q2 conducts. This closes Q10 and leaves Q9 and Q11 subject to the false state of the millidrive line, which turns on Q3, grounding the $\overline{\text{millidrive}}$ line and closing AND gate Q11. AND gate Q9 is opened, lighting NE2. This decimal shift two places to the right is matched by the lighting of the MILLI portion of the MILLIVOLTS display because the grounding of the X10 line is coupled to the millidrive output line through OR diode CR1. When .1V RANGE and 1 SEC SAMPLE PERIOD are selected, the NE4 and millidrive lines are both true (near groun(When the X10 line is also true, gates Q9 and Q10 are closed an(Q11 is opened, lighting NE5. This decimal shift one place to th left converts the 000.000 MILLIVOLTS display to 00.0000 MILLIVOLTS display.

3.13 BLANKING LOGIC/TIME BASE SELECTION (A21) (Figures 4.10A 4.10C, and 4.34)

The blanking logic/time base selection circuitry combines appropriate operating logic signals to blank the decimal point lamps or the display and energize the 1000V attenuator range relay when programming is incomplete. It also selects one of the three standard time base frequencies (100 cps, 10 cps, or 1 cps) to gate the counter section when using one of the standard sample periods.

If programming is incomplete, no decimal points on the display are lighted, and the output of decimal point logic card A20 at pin 6 is negative. (See Figure 4.10C.) This negative signal is applied to a negative AND gate (Q5) on A21 via pin 17. This gate is opened when the instrument is not set up for making frequency measurements using a manual gate, providing a positive output (symbolized by the inversion dot on AND gate Q5. This positive output (gnd) is coupled through pin 19 to energize the 1000V attenuator relay, and is also coupled through a positive OR gate (CR6-7) to light neon lamp NE6. This prevents any of the decimal points from lighting when they should not.

In addition to the logic operation described above for incomplete programming, whenever frequency measurements are made using a manual gate (e.g., time interval measurements), no decimal point should be lighted. Under these conditions, a positive signal at pin 9 of A21 is coupled through positive OR gate CR6-7 to light neon lamp NE6.

The time base selection circuitry selects one of three standard time bases by opening one of three positive AND gates connected to the time base outputs of the decade dividers. For example, if a .01 SEC sample period is selected, the input at pin 16 of A21 will be negative (indicated by $\overline{.01\ \text{SEC}}$). (See Figure 4.10A.) This signal opens AND gate Q7. When the 100 cps signal from the decade divider goes positive, AND gate Q7 provides a positive output. This output is coupled through a positive OR gate to the gate control circuit on A17.

3.14 PRINTER COUPLING (A22) (Figures 4.10C and 4.36)

The printer coupling circuit translates decimal position, range, and function information to appropriate BCD codes for recording. The decimal position is a number from 0 through 7. This number (n) stands for a negative power of ten multiplier (i.e., 10^{-n}) that indicates the position of the decimal point on the recorded measurement for the selected units. For example, a printer coupling output of:

4999991 = 10^{-4} x 99999 + VDC = +9.9999 VOLTS

The range and function information is shown in Table 2.4.

The decimal position information is received from the outputs of the standard decimal point logic assembly, A20, (and DY-2411A Decimal Point Logic Card A30 if installed) and then interpreted by the logic networks on A22. The decimal point logic network on A22 translates millivolt readings on the DY-2401C display to equivalent readings in volts for the recording output. For example a reading of 0001.23 MILLIVOLTS on the DY-2401C is recorded as 50001231, indicating that the decimal point is five places to the left (i.e., 0.00123) and the function is +VDC.

3.15 DY-2410B AC AND OHMS DELAY GATE (A23) (Figure 4.38)

The ac and ohms delay gate delays measurements as required when a DY-2410B AC/Ohms Converter is used with the DY-2401C. The delays provided differ with the type of measurement, as follows:

Type of Measurement	Delay (Milliseconds)
AC (Normal)	500-550
AC (Fast)	200-220
Ohms	100-110

The programming of a measurement using the DY-2410B cuts off Q2 through OR diode CR5, CR6, or CR7, opening AND gate Q2-CR8. Each negative reset pulse from the reset bus is then passed through the AND gate, triggering flip-flop Q3-Q4. The negative-going output from the Q4 collector is coupled through emitter follower Q1 to a resistance-capacitance (r-c) delay circuit. The negative output from the Q1 emitter allows capacitor C1 of the r-c delay circuit to charge negatively at a rate that is determined by circuit resistance.

When the negative voltage across capacitor C1 reaches a certain level, the flip-flop is driven to its original state. The delay tin required for this action is determined by the measurement functi that is programmed. When ohms is programmed, resistors R1, R2, and R3 are effectively connected in parallel through diodes CR2 and CR4, thus providing the minimum delay of 100-110 milliseconds. When AC Fast is programmed R2 and R3 are in para lel, providing a longer delay of 200-220 milliseconds. When AC normal is programmed, R3 determines the longest delay, which 500-550 milliseconds.

While the flip-flop is in the reset-triggered delay state, a negative-going pulse, coupled via non-inverting amplifier Q5, blanks the trigger input to the second time base divider, A2. The tran tion of Q3-Q4 to non-delay state triggers the 4-millisecond one-shot, Q6-Q7. The output pulse from the Q6 emitter prolongs the measurement delay an additional 4 milliseconds. After this dela the time base sample gate is generated as usual.

3.16 DY-2410B UNITS COUPLING (A9) (Figures 4.10C and 4.20)

The DY-2410B units coupling circuit is required when a DY-2410 AC/Ohms Converter is used. This circuit interprets the prograr med range and function inputs and provides output signals to light the appropriate units and decimal on the digital display.

When the 10 megohm range is programmed by a ground connection to pin 15 of A9, the signal is coupled through A9 to light the "MΩ" lamp on the units display, and to the 10 volt logic line to position the decimal point on the digital display. At the same time, this signal is coupled through a positive OR gate to cut off transistor AND gate Q3 so that the "KΩ" lamp cannot be lighted. The blanking of the KΩ lamp is necessary, because whenever the 10 megohm line is programmed, the ohms line is also programmed. This would ordinarily allow Q3 to conduct, lighting the

KΩ lamp. When the ohms line is programmed, the "VOLT", "MILLI" and polarity lamps are blanked.

The KΩ lamp will light under measurement conditions equivalent to those which light the VOLT lamp when voltage measurements are made. This requires that the 10 megohm and milli-drive lines not be programmed (i. e., negative) and that the ohms line be programmed (i. e., positive). The ohms line is always programmed for resistance measurements.

The "Ω" lamp lights when the milli-drive and ohms lines are positive and when the frequency and manual gate lines are negative. (The Ω lamp is equivalent to the MILLI and VOLTS lamps when voltage measurements are made.)

The programming of AC measurements grounds pin 8, lighting the AC lamp. The programming of either AC or ohms measurements has two additional effects. The polarity blanking amplifier, A16Q24, is cut off, blanking the polarity outputs from the counter control assembly. The positive true (ground) state of the AC or ohms logic line is connected to the attenuator coupling logic on A8, energizing 1V range relay A28K2 and causing all other attenuator range relays to be de-energized. This is done because all measurements made with the DY-2410B must use the 1V range of the DY-2401C.

3.17 -35 VOLT REGULATOR AND RESET CIRCUIT (A7) AND +6V BIAS CIRCUIT (A29)

3.17.1 A7 Reset Circuit (Figures 4.10A and 4.16)

The reset circuit on card A7 is designed to provide counter section reset pulses in response to pulse or contact-closure reset triggering. Pin 12 of A7, the closure input to the reset circuit, is connected to the front-panel RESET pushbutton and to pin "c" of rear-panel PROGRAM CONTROL connector J1. When pin 12 is grounded, a Schmitt trigger, Q4-Q5, is flipped after a delay of approximately 3 milliseconds. This delay is caused by an integrating network, R17-C2 which discharges toward ground when pin 12 is grounded. This network smooths out irregularities in the input signal caused by contact bounce, preventing the triggering of multiple reset signals. When the voltage across C2 reaches the emitter bias level, the Schmitt trigger is flipped as Q4 is cut off. The output of the Schmitt trigger is

a fast-rising, positive-going pulse which is coupled out pin 9 to reset the display timing flip-flop on A18 to the non-display state. The Schmitt trigger output, amplified and inverted by Q7, is also coupled as a negative-going pulse to the reset buss. This pulse resets the decade counting units, the decade dividers, and the overload detector.

Pin 14 of A7 is a second input to the reset circuit that is connected to the rear panel COUNTER RESET receptacle J4. The reset circuit is designed to respond to a negative 15-volt, 25-microsecond reset pulse with a rise-time of less than 2 microseconds. The pulse reset signal is assumed to be much cleaner than a contact closure signal applied at pin 12, and therefore the pulse is simply amplified and inverted by Q6 and Q7 coupled out pins 9 and 8 as previously mentioned.

3.17.2 A7 -35 Volt Regulator (Figure 4.16)

The -35 volt regulator provides regulated -35 vdc power for the transistorized circuits of the DY-2401C and the BCD reference level voltages that are required by an (hp)562A Digital Recorder. The + reference on pin 4 of A7, approximately -2 vdc, is the reference for a binary "1". The - reference on pin 6, approximately -25 vdc, is the reference for a binary "0". These reference levels are connected to rear-panel BCD OUTPUT receptacle J2.

The -35 volt regulator circuit consists of a differential amplifier, Q2-Q3, and an emitter follower, Q1. The output from Q1 is coupled externally by a chassis-mounted emitter follower, Q3, to series regulators Q1 and Q2. The series regulators are on a chassis-mounted heat sink. The regulator output is set at -35 volts b means of variable resistor R10. Differential amplifier Q2-Q3 con pares the potential tapped by R10 with that developed across resis tor R6. Output voltage variations, coupled through breakdown diode CR1, amplified and inverted by Q2-Q3, and coupled by Q1 prc vide the negative feedback that regulates the -35 volt output. The negative feedback from the amplifiers on A7 increases or decreases conduction through the chassis-mounted series regulators enoug to correct variations of output voltage almost completely.

3.17.3 A29 +6V Bias Circuit (Figure 4.16)

The +6V bias circuit on card A29 supplies regulated positive 6 vdc bias to counter control card A16 and reversible counting

decades A11-A15 and A46. In addition, rectifier-filter circuits mounted on this card (A29) provide unregulated +150 vdc and -150 vdc outputs to the digital and decimal displays.

The +6 volt reference is provided by voltage breakdown diode CR3. The potential dropped across CR3 is coupled to the +6 volt bias line by emitter follower Q1.

3.18 POWER SUPPLY FILTER (A36), SERIES REGULATOR (A34), AND CALIBRATION STANDARD (A35) (Figure 4.50)

3.18.1 Filter Board A36

Filter board A36 supplies rectified and filtered dc voltages to series regulator assembly A34 and to calibration standard assembly A35. It also provides rectified and filtered 300 vdc to the photochopper driver oscillator on A31.

3.18.2 Series Regulator Assembly A34

The series regulator assembly contains the circuits that control the positive and negative 12.3 vdc outputs of the DY-2401C power supply. These outputs power v-f converter assemblies A31, A32, and A33. The series regulators perform this function in response to inputs received from calibration standard assembly A35.

3.18.3 Calibration Standard Assembly A35

The calibration standard assembly contains the calibration standard supply and amplifiers that control the positive and negative 12.3 vdc series regulators. These circuits are discussed separately in the following paragraphs.

The negative 12.3 vdc output from the power supply is set by potentiometer R9. Output voltage variations are fed back to series regulator A34Q1 through differential amplifiers Q10-Q11 and Q1-Q2 and dc amplifier A34Q2. Dc amplifier A34Q2, on series regulator card A34, provides the inversion necessary for negative feedback and regulation of the negative 12.3 volt output potential. The voltage reference of the negative 12.3 volt regulator amplifier is provided by avalanche diode CR1, in the base circuit of Q10.

The positive output voltage from the power supply is set by the negative output voltage, which is used as the reference for the positive regulator amplifier. The output voltage from the posi-

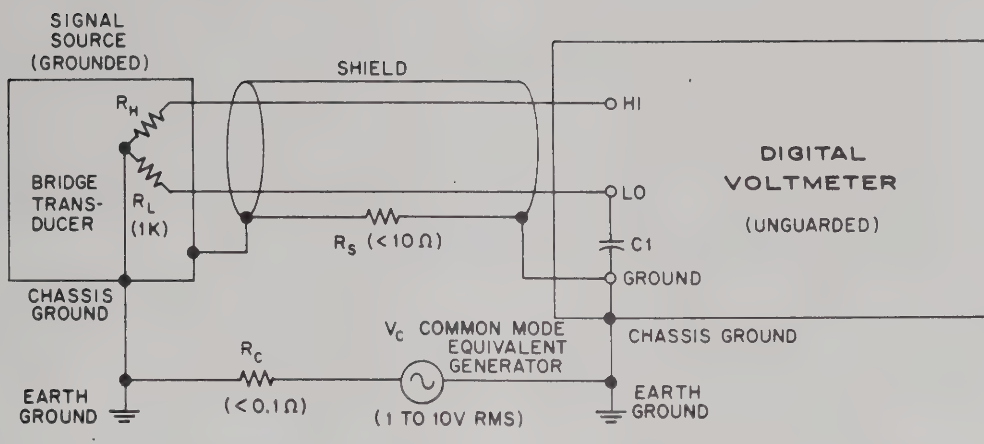
tive supply is held approximately equal in magnitude to that from the negative supply by emitter follower Q9, dc amplifier Q8, and series regulator A34Q3. Equal positive and negative voltages applied across divider R25-R26 place the Q9 base-emitter near ground potential. This allows conduction through dc amplifier Q8, which biases series regulator A34Q3 to conduct the load current required from the +12.3 vdc power supply circuit. Variation of the +12.3 vdc supply output potential with respect to the negative output is amplified and inverted by Q8. Negative feedback from the Q8 collector to series regulator A34Q3 largely corrects output voltage variations. Any increase or decrease of the negative output voltage establishes a new reference that causes a corresponding increase or decrease of the +12.3 vdc output potential. The positive regulator operates to keep the Q9 base-emitter near ground potential, which is the operating point of dc amplifier Q8.

The calibration standard circuit consists of voltage reference diode CR3, which is aged and selected for exceptional stability. The reference potential developed across this diode is compared with the output from series regulator Q4 by differential amplifier Q6-Q7. The inverted output from the collector of Q6 is coupled without inversion through a second differential amplifier, Q3-Q5, to series regulator Q4. The negative feedback thus provided holds the series regulator output voltage constant. This output is applied across a drift-compensated voltage divider network, from which is tapped the 1 volt output of the calibration standard.

3.19 REJECTION OF COMMON MODE AND SUPERIMPOSED NOISE

3.19.1 Rejection of Common Mode Noise

Common mode voltages are those dc and ac voltages that are common to both input leads of the Digital Voltmeter. These voltages result when the signal source ground and the Digital Voltmeter ground are not at the same potential. The potential difference between the signal source and the Digital Voltmeter grounds is the common mode voltage source. Unless precautions are taken, the common mode voltage source will cause unwanted currents to flow through the signal source impedance, producing a significant error in the signal voltage measurement. The proper way to eliminate this error is to break the common mode ground loop. In the DY-2401C the ground loop is broken by a technique



R_L = Source ground leg resistance.

R_S = Shield or ground bus resistance.

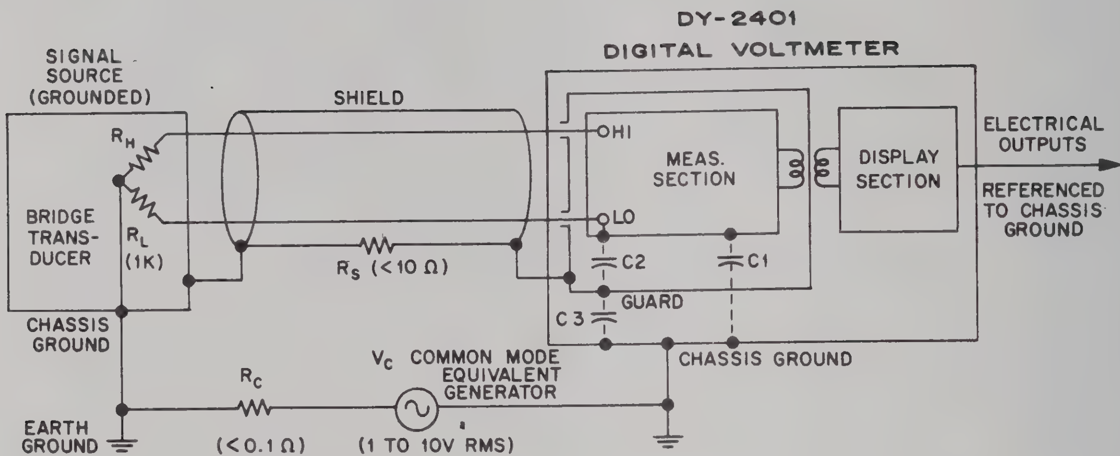
C1 = Capacitance, measuring circuit to chassis ground (typically 0.1 μf).

Figure 3.4 Typical Unguarded Input Circuit

known as guarding, in which the input to the Digital Voltmeter is completely isolated from the chassis and its associated ground.

Figure 3.4 shows a typical unguarded circuit where the common mode voltage source is represented by V_C. The ground loop currents of concern are those through the LO input side of the Digital Voltmeter (i.e., through R_C, R_L, C1); currents through the HI side are insignificant because of the high input impedance. With a typically large value of C1 (0.1 μf) and R_L = 1K, the common mode rejection (defined as the ratio between the common mode signal and the voltage it causes to be superimposed on the signal source) is limited to about 29 db at 60 cps. The common mode pickup can be minimized by utilizing a shield to shunt the common mode current path, but the additional rejection obtained is negligible because of the low value of R_C with respect to the shield resistance.

Figure 3.5 shows the guarded input circuit used in the DY-2401C. In this instrument the common mode ground loop is broken by using a separate "guard" shield to isolate the analog part of the measuring circuit from the chassis. Except for a slight voltage drop in R_S, the guard operates at the potential of the signal source, resulting in a negligible current through C2 and thus a negligible current through R_L. The circulating ground current forced by V_C is now effectively shunted away from the measuring circuit and flows through R_S and C3. By utilizing the guard shield the leakage capacitance (C1) between the measuring circuit and the chassis has



C1 = Stray capacitance, measuring circuit to chassis (< 2.5 pf).

C2 = Stray capacitance, measuring circuit to guard (.002 μf approx.)

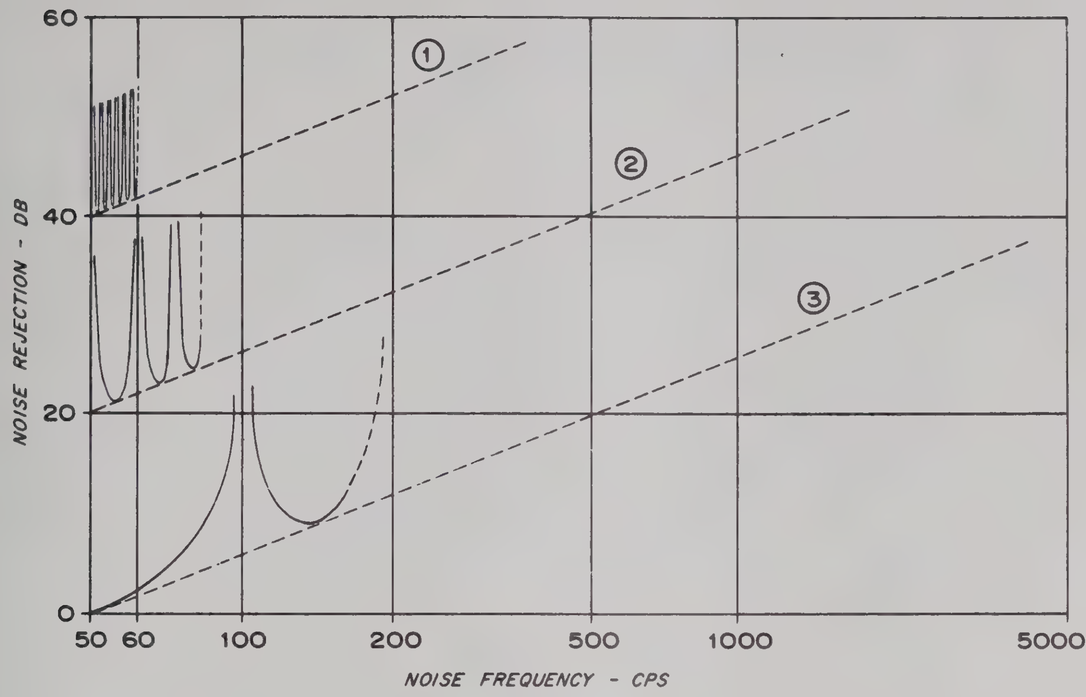
C3 = Stray capacitance, guard to chassis (.002 μf approx.)

Figure 3.5 DY-2401C Guarded Measurement Techniques

been reduced to less than 2.5 picofarads. Reduction of C1 to this low value yields a common mode rejection of 120 db at 60 cps (160 db at dc) even when the value of R_L is as much as 1000 ohms.

3.19.2 Rejection of Superimposed Noise

Superimposed noise voltages are primarily those unwanted ac signals that are superimposed on the input signal, usually as a result of electromagnetic pick-up from any ac field. When this occurs, the superimposed noise is added directly to the signal to be measured. Techniques used to combat common mode noise will not eliminate this type of noise since there is no ground loop to break. The problem of superimposed noise is effectively dealt with in the DY-2401C by the process of integration, in which the input signal is integrated over preselected sample period to obtain an average reading. If the period of the superimposed noise is such that its average value over



(1) 1.0 sec. sample period. Infinite rejection cusp every cycle.

(2) 0.1 " " " " " " " 10 cycles.

(3) 0.01 " " " " " " " 100 cycles.

Figure 3.6 Rejection of Superimposed Noise

the selected sample period is zero, no error results in the reading. For example, the fixed sample periods in the DY-2401C are multiples and submultiples of one second, and the average value of 60 cps ac noise over a one second interval is zero. As a result the instrument provides infinite rejection at 60 cps. Figure 3.6 shows a graph of rejection versus noise frequency at three different fixed sample periods. Note the infinite rejection cusps such as occur at 60 cps. At other frequencies, for example at 55 cps over a 0.1 sample period, 20 db of rejection is obtained. The rejection increases 20 db per decade (6 db per octave) increase in frequency.

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LIST OF TABLES

SECTION 4
MAINTENANCE

4.1 GENERAL

This section contains instructions for maintenance and servicing of the DY-2401C Integrating Digital Voltmeter. Included are instructions for in-cabinet performance checks, air filter servicing, troubleshooting, instrument cover removal, repair, and calibration. These instructions are supplemented by a list of recommended test equipment (Table 4.1), a maintenance schedule (Table 4.2), test setup and parts location illustrations, and troubleshooting, logic, and schematic diagrams (Figures 4.1 through 4.51).

4.2 IN-CABINET PERFORMANCE CHECKS

The In-Cabinet Performance Checks, Table 4.3, may be used to verify specifications of the equipment. The Performance Check Test Card, which follows Table 4.3, may be used as a permanent record of the instrument's performance when filled out. Values or answers in parenthesis below or to the right of test card entry blocks specify correct reading or reading tolerance. The entry numbers on the card correspond to the checks in Table 4.3. The checks in Table 4.3 and in Section 2.2 verify correct operation of all circuits in the DY-2401C and may be used:

a. as part of an incoming inspection check of instrument specifications;

b. periodically, as specified in Table 4.2 (or more frequently for instruments used in systems where maximum accuracy and reliability are of utmost importance);

c. as part of a troubleshooting procedure to locate malfunctioning circuits; and

d. after repairs or adjustments, before returning the instrument to regular service.

During the Performance Checks the DY-2401C should be connected to the ac line through a variable voltage device so that line voltage may be varied ±10% from nominal (115 or 230 vac) to assure that the instrument operates correctly at various supply voltages.

Table 4.1 Recommended Test Equipment

Instrument Type	Required Characteristics	Use	Recommended Model
DC Standard	0-1, 0-10, 0-100, 0-1000 vdc outputs accurate to ±0.01% stability ±0.003%.	Performance check and calibration.	ⓗⓟ740A DC Standard Differential Voltmeter with 11054A and 11055B Accessory Cables
Standard Frequency Source	100 kc, 1 cps outputs accurate to ±5 parts in 10^8.	Performance check and calibration of counter time base.	ⓗⓟ100E Frequency Standard
Oscilloscope	10-mc bandwidth, dual-trace plug-in, calibrated time base and vertical channel, ext sync capability.	Observe waveforms and measure timing relationships during performance checks, troubleshooting, and calibration.	ⓗⓟ175A Oscilloscope ⓗⓟ1750A Dual-Trace Vertical Amplifier ⓗⓟ10003A Voltage Divider Probe (2 each)
DC Null Voltmeter	Low range 0-3 μv, infinite impedance at null, operation independent of ac line.	Null sensing and voltage measurements during performance checks and calibration.	ⓗⓟ 419A DC Null Voltmeter
Precision Volt Box	1:1, 10:1, 100:1, 200:1, 300:1, 400:1, 500:1, 600:1, 700:1, 800:1, 900:1, 1000:1 resistance ratios accurate to ±.001% at 1000 Ω/v.	Performance checks and calibration.	
Variable Line Voltage Source with Meter	Variable from 103-127 vac (or 207-253 vac).	Performance checks.	

Table 4.1 (Cont'd)

Instrument Type	Required Characteristics	Use	Recommended Model
1 Volt Calibration Standard	1 vdc output calibrated from primary standard to ±0.001% accuracy.	Transfer standard for performance checks and calibration.	
Isolation Transformer	50-60 cycle, 115v primary, 1:1 ratio.	Common mode noise rejection check.	
Portable Oscillator	Sine wave output from 5 cps to 300 kc, operation independent of ac power line.	Performance checks and calibration.	hp 204B Portable Oscillator
AC Vacuum Tube Voltmeter	10, 30, 100, 300 mv ranges, measurement of rms voltage.	Performance check of superimposed noise rejection.	hp 400D VTVM
Test Oscillator	Sine wave output from 300 kc to 1.2 mc.	Performance check of DY-2401C-M29.	hp 650A Test Oscillator
Pulse Generator	-1v, 2 μs pulse output at 1 kc.	Performance check of frequency measurement sensitivity to pulse input.	hp 212A Pulse Generator
Square Wave Generator	Square wave output from 1 cps to 20 kc, 27v p-p from 600Ω output.	Performance check of pulsed counter resetting from external source.	hp 211A Square Wave Generator
BNC "T" Adapter			hp 1250-0072

Table 4.1 (Cont'd)

Instrument Type	Required Characteristics	Use	Recommended Model
Electronic Counter	Time interval measurements at 10 μs resolution.	Response time and measurement speed performance checks.	(hp)523C or D

Table 4.2 Maintenance Schedule

Recommended Interval *	Maintenance Operation
Daily, or each time the instrument is turned on.	For maximum accuracy of measurements perform pre-operational check and calibration per Section 2.2.
Weekly.	Verify accuracy of internal time base per check 3 of Table 4.3. If necessary, calibrate internal time base per Section 4.7.5.
Monthly.	Clean air filter per Section 4.3.
Every six months.	Calibrate internal 1v reference per Section 4.7.4. Perform checks 1 through 11 in Table 4.3. If necessary, calibrate overload detection per Section 4.7.3. If necessary, calibrate input attenuator per Section 4.7.8.

*More frequently under adverse operating conditions or when maximum accuracy and reliability are of utmost importance.

Table 4.3 In-Cabinet Performance Checks (Std. & M29 Instruments)

1. VOLTAGE MEASUREMENT RANGES

Full Scale Ranges: 0.1, 1, 10, 100, 1000V.
Overranging: To 300% of full scale except on 1000V range.
Overload Protection: DY-2401C switches to 1000V range at 310% of full scale.

a. Set DY-2401C Power switch to ON, other controls as follows:

FUNCTION:	VOLT
RANGE:	1000V
SAMPLE PERIOD:	1 SEC
SAMPLING RATE:	CLOCKWISE FROM STOP
100 KC STD (rear panel):	INT

b. Connect the + and -OUTPUT terminals of the DC Standard to the HI and LO terminals of the DY-2401C. Jumper the GUARD terminal to the LO terminal.

c. Turn on the DC Standard and set it to provide 1000V dc output. The DY-2401C display readout should approximate 1000.00 VOLTS.

d. Check DY-2401C operation on remaining ranges as follows:

DC Standard Output (Volts)	DY-2401C Range (Volts)	Approximate DY-2401C Display
100	100	+100.000 VOLTS
10	10	+10.0000 VOLTS
1	1	+1000.00 MILLIVOLTS
0.1	0.1	+100.000 MILLIVOLTS

e. Check DY-2401C overranging operation as follows:

DC Standard Output (Volts)	DY-2401C Range (Volts)	Approximate DY-2401C Display
0.3	0.1	+300.000 MILLIVOLTS
3	1	+3000.00 MILLIVOLTS
30	10	+30.0000 VOLTS
300	100	+300.000 VOLTS

f. Increase DC Standard output voltage slowly until OVERLOAD indicator lights on DY-2401C digital display. Set DY-2401C RANGE switch to 1000V and record reading, which should be within the range of +0308.00 to +0315.00 VOLTS. If outside this range, calibrate per Section 4.7.3.

Table 4.3 Cont'd

2. VOLTAGE MEASUREMENT - INTEGRATION OF POSITIVE AND NEGATIVE EXCURSIONS OF THE VOLTAGE MEASURED
The DY-2401C displays the true integral of the input signal with correct polarity even if the signal crosses through zero during the sample period.

a. With DY-2401C on and operating, set controls as follows:

SAMPLE PERIOD:	STOP
STORE/DISPLAY (rear panel):	DISPLAY
FUNCTION:	VOLT
RANGE:	INT - 1V

b. Set DY-2401C SAMPLE PERIOD switch to START until 6-digit negative count is accumulated; then set switch to STOP.

c. Set DY-2401C RANGE switch to INT +1V and reset SAMPLE PERIOD switch to START. Observe counting down to zero (visible on the two most significant digits), reversal of polarity indication to +, and count up of +voltage. Set SAMPLE PERIOD switch to STOP and record observations.

NOTE
If it is desired to view this process in greater detail, apply an input voltage that is about 1/10 or 1/100 of the full scale range selected. After the initial count is accumulated, reverse this input.

3. INTERNAL TIME BASE
Frequency: 100 kc.
Stability: Aging Rate $<\pm 2$ parts in 10^6 per week.
Temperature $<\pm 100$ parts in 10^6 over range of 10-50°C.

a. Turn on DY-2401C, the Frequency Standard, and the Oscilloscope; note time.

b. Set 100 KC STD switch on rear of DY-2401C to INT position.

c. Connect a BNC cable from the 100 KC STD OUTPUT/INPUT receptacle, J3, on the rear of the DY-2401C to a vertical input of the Oscilloscope.

Table 4.3 Cont'd

3.	INTERNAL TIME BASE (Cont'd)
d.	Synchronize the Oscilloscope externally from the 1 cps output of the Frequency Standard.
e.	Set Oscilloscope for 1 μSEC/CM sweep rate and for convenient display of the 1.2V p-p, 100 kc square wave time base output from the DY-2401C.
f.	After the DY-2401C has been operating for at least an hour, observe square wave display on Oscilloscope to determine degree of drift, if any. Left drift is -, right drift is +.
g.	The horizontal drift of the square wave in CM/SEC is the difference between the Standard Frequency and the Counter time base frequency in parts in 10^6. Determine this difference and record it on the Performance Check Test Card. NOTE Temperature must be within ±5°C of the temperature at which internal time base oscillator was calibrated. If a record of the temperature and date of last calibration is not available, the frequency offset should not be considered drift or aging rate of the 100 kc crystal. For calibration instructions, see Section 4.7.5.
h.	Check long term stability by repeating the procedure of steps a through g one week later.
i.	If a precisely controlled temperature chamber is available, check temperature stability by repeating the procedure of steps a through g after the DY-2401C has been on and operating at 10°C for at least 1-1/2 hours, but use 10 μSEC/CM sweep rate. Repeat at 50°C. The horizontal drift of the square wave in CM/SEC is the difference between the standard frequency and the Counter time base in 10 parts in 10^6. Determine frequency difference, which should be no greater than ±100 parts in 10^6.
4.	INTERNAL CALIBRATION SOURCE Voltage: 1V ±.002% (after factory adjustment). Drift: <±.006% in six months. Temperature Coefficient: 10-40°C: ±.001% per °C. 40-50°C: ±.0015% per °C.

Table 4.3 Cont'd

4. INTERNAL CALIBRATION SOURCE (Cont'd)

a. Set DC Standard for 1V output.

b. Zero the DY-2401C per the procedure in Section 2.2.2.

c. Connect the DC Standard, DC Null Voltmeter, 1V Calibration Standard, Precision Volt Box, and DY-2401C as shown in Figure 4.1(A). Operate the DC Null Voltmeter from its internal batteries; do not connect it to the ac line.

d. Set the DC Standard output voltage to produce a null on the most sensitive range of the DC Null Voltmeter.

e. Set the DY-2401C to 1V RANGE and set the CAL+ adjustment for +1000.00 MILLIVOLTS indication on the digital readout.

f. Reverse the connections of leads 2 and 4 to the DY-2401C HI and LO terminals and set the CAL- adjustment for -1000.00 MILLIVOLTS indication on the digital readout.

g. Set the DY-2401C RANGE switch to INT -1V and record the second digital readout. This reading should be within ±0.08 mv of -1000.00 MILLIVOLTS (maximum drift to ±0.006% ±1 digit ± accuracy of voltage standard).

NOTE
Immediately after calibration (see Section 4.7.4), at the calibration temperature, the next digital readout should be within ±0.03 mv of -1000.00 MILLIVOLTS (initial calibration to ±0.002% ±1 digit).

h. Check long term stability by repeating the procedure of steps a through g monthly for six months.

NOTE
If a precisely controlled temperature chamber is available, the temperature coefficient of the internal calibration source may be checked per the procedure of steps i through l.

i. Hold the DY-2401C on and operating at 40°C (±1°) for at least 1-1/2 hours.

Table 4.3 Cont'd

4.	INTERNAL CALIBRATION SOURCE (Cont'd)
j.	Repeat steps a through d, above, to obtain a 1V ±0.001% external standard.
k.	Read voltage of external standard on 1V range; then read voltage from internal calibration source on corresponding INT 1V range and subtract the difference in readings. This difference should be no greater than ±0.17 mv.
l.	Repeat the procedure of steps i through k, above, at 50°C and 10°C. The 50°C difference should be no greater than ±0.30 mv; the 10°C difference should be no greater than ±0.17 mv.
5.	VOLTAGE MEASUREMENT - FULL SCALE ACCURACY At 25°C: ±.01% rdg ±.005% fs ±1 digit (1). Temperature Coefficients: 10-40°C: ±.001% rdg per °C (2). 40-50°C: ±.0015% rdg per °C (2). (0.1V Range) ±.002% rdg ±.0005% fs per °C (3). (Other Ranges) ±.002% rdg ±.0002% fs per °C (3). (1) Holds for all ranges, assuming daily calibration against internal standard - calibration of internal standard every six months - line voltage variation no greater than ±10%. (2) When calibrated against internal standard at operating temperature. (3) Over the range of 10-50°C when calibrated against internal standard at 25°C.
a.	With ambient temperature at 25°C and controls set as at end of check 4, set the CAL- adjustment for -1000.00 MILLIVOLT reading on the DY-2401C digital display.
b.	Set the DY-2401C RANGE switch to INT +1V and set the CAL+ adjustment for +1000.00 MILLIVOLT reading on the digital display.
c.	Set the DY-2401C to 1V RANGE and set the DC Standard to produce a null on the most sensitive range of the DC Null Voltmeter (connections are as at end of check 4).

Table 4.3 Cont'd

5. VOLTAGE MEASUREMENT - FULL SCALE ACCURACY (Cont'd)

NOTE: A
All voltage reading tolerances noted in this check include the potential inaccuracy of the external voltage standard (±0.001% for 1V, ±0.002% for other voltages).

NOTE B
If any range is out of tolerance at 25°C ambient, calibrate per Section 4.7.8.

d. Record the next readout. This reading should be within ±0.17 mv of -1000.00 MILLIVOLTS.

e. Connect leads 2 and 4 as shown in Figure 4.1(A) and record the next readout. This reading should be within ±0.17 mv of +1000.00 MILLIVOLTS.

f. Change connections to those shown for .1V check in Figure 4.1(B) and set the DY-2401C RANGE switch to .1V. Record the next digital readout. This reading should be within ±0.018 mv of ±099.108 MILLIVOLTS.

NOTE
The 100K input impedance of the DY-2401C on the .1V RANGE loads the output of the Precision Volt Box so that the input voltage is +99.108 mv. The accuracy tolerances total ±18 μv for this reading, scale, and digits, including the ±0.002% accuracy of the voltage source.

g. Change connections to those shown for 10V check in Figure 4.1(B). Set the DY-2401C RANGE switch to 10V and set the DC Standard to exactly 10V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter.

h. Record the next reading. This reading should be within ±0.0018V of +10.0000 VOLTS.

i. Change connections to those shown for 100V check in Figure 4.1(B). Set the DY-2401C RANGE switch to 100V and set the DC Standard to exactly 100V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter.

Table 4.3 Cont'd

5.	VOLTAGE MEASUREMENT - FULL SCALE ACCURACY (Cont'd)
j.	Record the next reading. This reading should be within ±0.018V of +100.000 VOLTS.
k.	Change connections to those shown for 1000V check; set the DY-2401C RANGE switch to 1000V and set the DC Standard to exactly 1000V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter.
l.	Record the next reading. This reading should be within ±0.18V of +1000.00 VOLTS. NOTE If a precisely controlled temperature chamber is available, the temperature coefficient of voltage measurement may be checked per the procedure of steps m through o.
m.	Hold the DY-2401C on and operating at 40°C (±1°) for 1-1/2 hours.
n.	Repeat steps c through e, and determine the difference between the readings for 1V input at 25°C and 40°C, which should be not greater than ±0000.35 mv.
o.	Repeat the procedure of steps m and n, above, at 50°C and 10°C. The 50°C difference should be no greater than ±0000.57 mv; the 10°C difference should be no greater than ±0000.35 mv.
6.	VOLTAGE MEASUREMENT - LINEARITY At 3 Times Full Scale: ±.025% rdg ±1 digit (1). At 2 Times Full Scale: ±.02% rdg ±1 digit (1). At Less Than Full Scale: ±.01% rdg ±.005% fs ±1 digit (1). (1) Ambient temperature at 25°C, line voltage variation no greater than ±10%.
a.	With ambient temperature at 25°C and controls set as at end of check 5, set DC Standard for output of approximately 3 vdc.
b.	Connect the DC Standard, DC Null Voltmeter, 1V Calibration Standard, Precision Volt Box, and DY-2401C for 3X check as shown in Figure 4.1(A) and (B).

6. VOLTAGE MEASUREMENT - LINEARITY (Cont'd)

c. Set the DC Standard to exactly 3V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter.

NOTE
All voltage reading tolerances noted in this check include the potential inaccuracy of the external voltage standard (±0.002%).

d. Set the DY-2401C RANGE switch to 1V and record the next reading. This reading should be within ±0.82 mv of +3000.00 MILLIVOLTS.

e. Reverse the connections to the HI and LO terminals of the DY-2401C and record the next reading.

f. Change connections to those shown in Figure 4.1B for 2X check.

g. Set the DC Standard to exactly 2V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter. Record the next reading. This reading should be within ±0.45 mv of -2000.00 MILLIVOLTS.

h. Reverse the connections to the HI and LO terminals of the DY-2401C and record the next reading.

i. Change connections to those shown in Figure 4.1(B) for 10% fs interval linearity checks and set the DC Standard for 900V output.

j. In turn, connect lead from HI input terminal of the DY-2401C to each of the terminals of the Precision Volt Box that are listed following this step and reset output from the DC Standard for a precise null reading on the most sensitive range of the DC Null Voltmeter. At each point, record the reading.

Precision Volt Box Terminal			Reading	Tolerance
900:1	90%	% of Full Scale	+0900.00V	±0.17V
800:1	80%		+0800.00V	±0.16V
700:1	70%		+0700.00V	±0.14V
600:1	60%		+0600.00V	±0.13V
500:1	50%		+0500.00V	±0.12V
400:1	40%		+0400.00V	±0.11V
300:1	30%		+0300.00V	±0.10V
200:1	20%		+0200.00V	±0.08V
100:1	10%		+0100.00V	±0.07V

Table 4.3 Cont'd

7.	VOLTAGE MEASUREMENT - REJECTION OF COMMON MODE NOISE 140 db.
a.	With the DY-2401C on and operating, connect only the equipment shown in Figure 4.1(C). Set variable voltage transformer for minimum output voltage.
b.	On the DY-2401C, select .1V RANGE and 1 SEC SAMPLE PERIOD. Set SAMPLING RATE control fully clockwise and record the next reading
c.	Increase output voltage from the variable transformer to maximum, or until the reading on the DY-2401C changes more than ±2 digits. Determine and record rms voltage across secondary of the isolation transformer.
d.	Repeat the procedure of steps a through c for .1 and .01 SEC SAMPLE PERIODs. The common mode line frequency signal required to produce the specified change in reading should be greater than 100V rms at each sample period.
8.	VOLTAGE MEASUREMENT - REJECTION OF SUPERIMPOSED NOISE <u>At 55 CPS, 0.1 Sec Sample Period</u>: >20 db <u>At 550 CPS, 0.1 Sec Sample Period</u>: >40 db (1). (1) Increases 20 db per decade increase in frequency.
a.	Connect test equipment as shown in Figure 4.1(D); connect the output of the Portable Oscillator to the FREQ INPUT of the DY-2401C.
b.	Set controls of the DY-2401C as follows: FUNCTION: FREQ SAMPLE PERIOD: 1 SEC SAMPLING RATE: FULLY CLOCKWISE ATTENUATION: FULLY CLOCKWISE
c.	Turn on the Portable Oscillator and set it to provide 000.055 kc output, as counted by the DY-2401C.

Table 4.3 Cont'd

8. (Cont'd)

d. Disconnect the output of the Portable Oscillator from the DY-2401C FREQ INPUT and connect it instead between the 10:1 terminal of the Precision Volt Box and the signal line to the HI input terminal of the DY-2401C.

e. On the DY-2401C reset controls as follows:

FUNCTION:	VOLT
RANGE:	10V
SAMPLE PERIOD:	.1 SEC

f. Set the Portable Oscillator for minimum output amplitude and note the reading displayed by the DY-2401C.

g. Slowly increase the Portable Oscillator output amplitude until the 10 mv digit (second from right) changes.

h. Determine and record the rms output from the Oscillator. More than 100 mv rms (20 db greater than the second, 10 mv digit) should be required to produce the specified change in the DY-2401C reading.

i. Repeat steps a through c, above, but set the Portable Oscillator to provide 000.550 kc output as counted by the DY-2401C.

j. Repeat steps d through h, above. More than 1V rms (40 db greater than the 10 mv digit) should be required to produce the specified change in the DY-2401C reading.

NOTE

If desired, a similar technique can be used to verify the noise rejection of the DY-2401C for other sample periods and other frequencies. See Figure 3.6 for superimposed noise rejection characteristics with respect to noise frequency and sample period.

Table 4.3 Cont'd

9.	FREQUENCY MEASUREMENT RANGE - 5 CPS TO 300 KC (TO 1.2 MC WITH M29)
a.	Set DY-2401C Power switch to ON, other controls as follows: FUNCTION: FREQ SAMPLE PERIOD: 1 SEC SAMPLING RATE: CLOCKWISE FROM STOP ATTENUATION: FULLY CLOCKWISE
b.	Connect output of Portable Oscillator to DY-2401C FREQ INPUT and to an Oscilloscope with a BNC "T" connector.
c.	While holding Oscillator output amplitude constant at 0.1V rms (0.28V p-p), vary the output frequency downward from 100 kc to determine the lowest frequency that is counted reliably. Then increase Oscillator frequency to determine highest frequency that is counted reliably. Record lowest and highest frequencies. NOTE For high end testing of DY-2401C-M29 instruments, substitute a Test Oscillator for the Portable Oscillator and increase frequency from 300 kc with amplitude set at 0.5V rms (1.4V p-p) to determine the highest frequency that is counted reliably. Record this frequency.
10.	FREQUENCY MEASUREMENT - SENSITIVITY Sine Wave Input (Std DY-2401C): 0.1V rms (max.) at 300 kc Sine Wave Input (DY-2401C-M29): 0.5V rms (max.) at 1 mc Pulse Input (DY 2401C Std. or M29: (1) (1) Polarity: Negative Minimum Peak Amplitude: 1V, maximum Minimum Duration: 2μs, maximum
a.	At 300 kc, increase amplitude of Oscillator output from zero until consistent measurement is obtained.
b.	Determine and record the rms output voltage from the Oscillator (use AC VTVM); the voltage should be no greater than 0.1V rms.
c.	Check 1 mc sensitivity of M29 instruments with the Test Oscillator set for 999.999 kc output. Increase Oscillator output from

Table 4.3 Cont'd

10. FREQUENCY MEASUREMENT - SENSITIVITY (Cont'd)

c. zero until consistent measurement is obtained. Then determine and record the output voltage, which should be no greater than 0.5V rms.

d. Connect output of Pulse Generator to DY-2401C FREQ INPUT and to input of Oscilloscope with a BNC "T" connector.

e. Set Pulse Generator for negative 1V, 2 μs pulse with 1 kc repetition rate.

f. Increase pulse amplitude from minimum until consistent measurement is obtained. Record the peak amplitude, which should be no greater than 1V.

g. Set pulse amplitude at 1V and increase pulse duration from minimum until consistent measurement is obtained. Record the duration, which should be no greater than 2 μs.

11. RESPONSE TIME AND MEASUREMENT SPEED
Response time and selected sample period determine measurement speed, as follows:

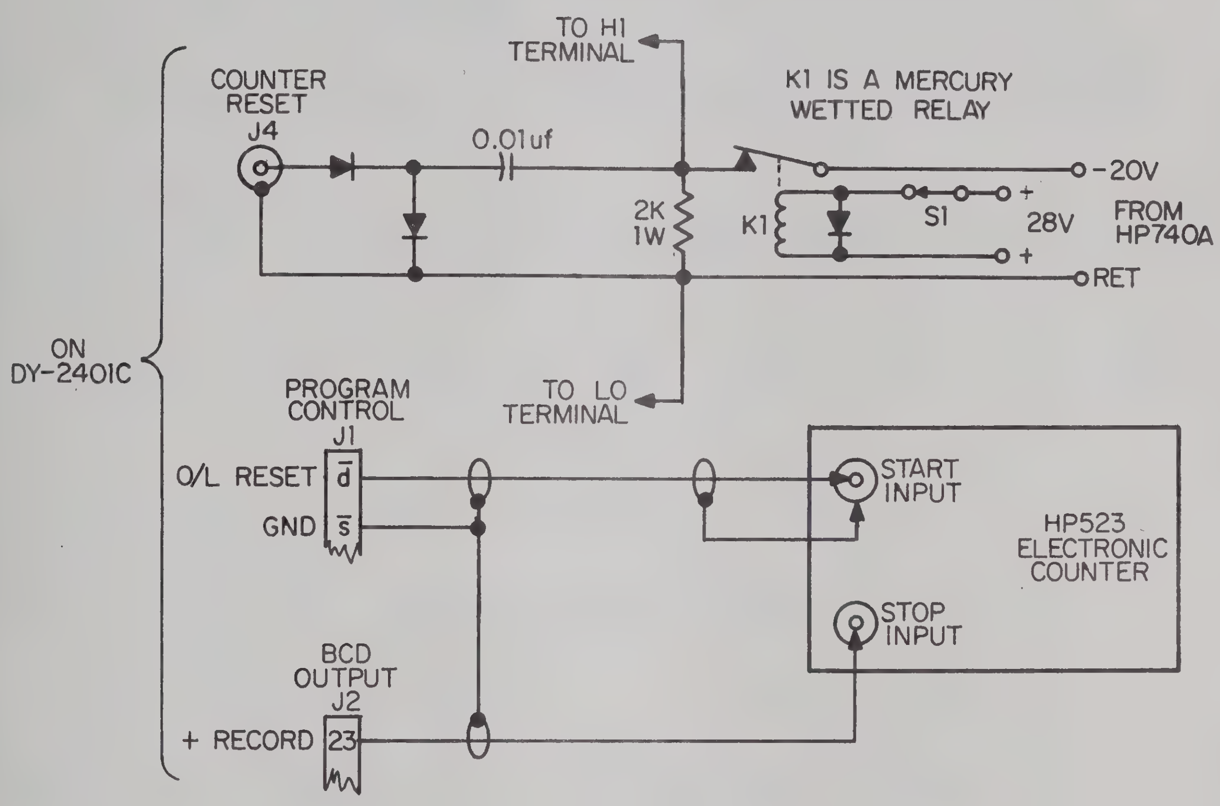
Response Time (MS)	+	Sample Period (SEC)	=	Measurement Time (MS)	Approximate Measurement Speed (Readings/Sec)
9.67		0.01		19.67	50
9.67		0.1		109.67	9
9.67		1.0		1009.67	1

a. Connect test equipment as indicated on following page; close S1 to energize K1. Set DC Standard for 20v output. With DY-2401C on and operating, set controls as follows:

FUNCTION:	VOLT
RANGE:	10V
SAMPLE PERIOD:	1 SEC
SAMPLING RATE:	CLOCKWISE FROM STOP
100 KC STD (rear panel):	INT

Table 4.3 Cont'd

11. RESPONSE TIME AND MEASUREMENT SPEED (Cont'd)



b. Set the Electronic Counter for time interval measurement in ms, started by positive-going input and stopped by negative-going input. Time interval readings on the Electronic Counter should be 29.67 ms ±1 count. Voltage readings on the DY-2401C should be approximately -20.0000 VOLTS. Record voltage reading, then set the DY-2401C SAMPLING RATE control to STOP.

c. Open S1 to de-energize K1, disconnecting the 20v input to the DY-2401C. Then reset the DY-2401C and the Electronic Counter. The DY-2401C should now read 0v ±1 count.

Table 4.3 Cont'd

11.	RESPONSE TIME AND MEASUREMENT SPEED (Cont'd)
d.	Close S1 to energize K1, connecting the -20v. Then record the reading on the Electronic Counter and the difference between this voltage reading on the DY-2401C and that previously recorded. The counter reading should be 9.67 ms ±0.01 ms, and the voltage reading on the DY-2401C should be within ±0.0002 VOLTS of that recorded in step b, above.
e.	Set the Electronic Counter for time interval measurement stopped by positive-going input and repeat steps c and d, above, at .01 SEC, .1 SEC, and 1 SEC sample periods. Record the Electronic Counter readings, which should be as follows (±1 count): Sample Period (SEC) — Time Interval Reading (ms) .01 — 19.67 .1 — 109.67 1. — 1009.67
12.	TIME BASE - OUTPUT (REAR PANEL) 100 kc square wave. Negative 1.2V p-p. 1K output impedance.
a.	With DY-2401C on and operating, connect Oscilloscope to rear panel 100 KC STD OUTPUT/INPUT receptacle, J3.
b.	Check Oscilloscope; it should display a 100 kc square wave, negative-going to 1.2V. Record the signal amplitude.
c.	The output impedance is determined by a fixed value 1K resistor (R15), which can be seen in the assembly A6 circuit diagram, Figure 4.14.
13.	TIME BASE - EXTERNAL INPUT (REAR PANEL) 2V p-p maximum into 1.2K.
a.	Set 100 KC STD switch on the rear panel of the DY-2401C to EXT position; leave all other DY-2401C controls at the settings used in checks 9 and 10.

Table 4.3 Cont'd

13. TIME BASE - EXTERNAL INPUT (REAR PANEL)

b. Connect 100 kc, 2V p-p output, from the Portable Oscillator to the DY-2401C FREQ INPUT and 100 KC STD OUTPUT/INPUT receptacle with a BNC "T" connector.

c. Set ATTENUATION control fully clockwise and increase Oscillator output amplitude from minimum to the point where consistent measurement is obtained.

d. Determine and record the peak-to-peak amplitude of the Oscillator output.

e. The input impedance is determined by a fixed value 1.2K resistor (R6), which can be seen in the assembly A6 circuit diagram, Figure 4.14.

---

14. RECORDING OUTPUTS - BCD DATA
6 digits.
4-line 4-2'-2-1 code.
<u>"0" State Level:</u> -35 to -24.5V.
<u>"1" State Level:</u> -2.5 to 0V.
<u>Source impedance:</u> 100K.

---

a. On the DY-2401C, change control settings as follows:

100 KC STD (rear panel):	INT
SAMPLE PERIOD:	START
ATTENUATION:	CHECK

b. Connect a 10 pf, 10X attenuation, 10 meg probe to one channel of the Oscilloscope.

c. Connect the probe to the following pins of J2 to verify "0" and "1" state levels for each data digit. These levels will be represented by a 22-35v p-p square wave. (The square wave frequency differs at each pin of J2. Record a yes on the test card for each correct 4-line digital output.

Digit	Decade	J2 Pins	Digit	Decade	J2 Pins
10^0	A11	3, 4, 28, 29	10^3	A14	9, 10, 34, 35
10^1	A12	5, 6, 30, 31	10^4	A15	11, 12, 36, 37
10^2	A13	7, 8, 32, 33	10^5	A46	13, 14, 38, 39

Table 4.3 Cont'd

14. RECORDING OUTPUTS - BCD DATA (Cont'd)

d. The source impedance is determined by fixed value 100K resistors, which can be seen in the assembly A11-15, 46 circuit diagram, Figure 4.24.

15. RECORDING OUTPUTS - BCD FUNCTION
1 digit.
4-line 4-2'-2-1 code.
"0" State Level: -35 to -24.5V.
"1" State Level: -2.5 to 0V.
Source Impedance: 33K.

a. Determine and record dc function levels at the following pins of J2:

Function	J2 Pin / Code	41 / 4	40 / 2'	16 / 2	15 / 1	Control Settings
+VDC		0	0	0	1	VOLTS, INT +1V
-VDC		0	0	1	0	VOLTS, INT -1V
KC		0	0	1	1	FREQ
KΩ (W/DY-2410B)		0	1	1	0	EXT SEL, 1V
MΩ (W/DY-2410B)		0	1	1	1	EXT SEL, 1V
OVERLOAD		1	1	1	1	VOLTS, 1V (1)
VAC (W/DY-2410B)		1	0	0	1	EXT SEL, 1V

(1) With dc input sufficient to produce OVERLOAD indication.

b. The source impedance is determined by fixed value 33K resistors, which can be seen in the assembly A22 circuit diagram, Figure 4.36.

16. RECORDING OUTPUTS - BCD DECIMAL POINT
1 digit.
4-line 4-2'-2-1 code.
"0" State Level: -35 to -24.5V.
"1" State Level: -2.5 to 0V.
Source Impedance: 33K.

a. Set DY-2401C FUNCTION switch to VOLT, other controls as specified below; determine and record dc decimal levels at the following

Table 4.3 Cont'd

16. RECORDING OUTPUTS - BCD DECIMAL POINT (a, Cont'd)

pins of J2; short-circuit HI, LO, and GUARD terminals to assure all zeros reading.

Control Settings Range(V)	Sample Period	Decimal Position	J2 Pin Code	27 4	26 2'	2 2	1 1	
1000	.01 Sec	000000. V		0	0	0	0	(10^{-0})
1000	.1 Sec	00000. 0V		0	0	0	1	(10^{-1})
100	.1 Sec	0000. 00V		0	0	1	0	(10^{-2})
10	.1 Sec	000. 000V		0	0	1	1	(10^{-3})
1	.1 Sec	00. 0000V		0	1	1	0	(10^{-4})
.1	.1 Sec	0000. 00V		0	1	1	1	(10^{-5})
.1	1.0 Sec	000. 000MV		1	1	0	0	(10^{-6})
.1	1.0 Sec	00. 0000MV (1)		1	1	0	1	(10^{-7})

(1) With DY-2411A Guarded Data Amplifier operated at +10 gain (10 MILLIVOLTS full scale); FUNCTION switch set to EXT SEL position; DY-2411A Decimal Point Logic Card A30 instal- led.

b. Set DY-2401C FUNCTION switch to FREQ, ATTENUATION control just clockwise from switched CHECK position, other controls as specified below; use DC Null Voltmeter to check decimal levels at the following pins of J2:

Sample Period	Decimal Position	J2 Pin Code	27 4	26 2'	2 2	1 1	
.01 Sec	00000. 0 KC		0	0	0	1	(10^{-1})
.1 Sec	0000. 00 KC		0	0	1	0	(10^{-2})
1. Sec	000. 000 KC		0	0	1	1	(10^{-3})
STOP	000000 KC		0	0	0	0	(10^{-0})

c. The source impedances are determined by fixed value 33K resistors, which can be seen in the assembly A22 circuit diagram, Figure 4.36.

17. RECORDING OUTPUTS - REFERENCE LEVELS
"0" State Level: -24.5 to -21.5V. Source Impedance: 800Ω.
"1" State Level: -5 to -4V. Source Impedance: 380Ω.

a. Set DY-2401C Power switch to ON.

Table 4.3 Cont'd

17.	RECORDING OUTPUTS - REFERENCE LEVELS (Cont'd)
b.	Connect DY-2401C LO terminal to J2, pin 50 and connect HI terminal to J2 pins as specified below and record readings. HI Terminal To J2 Pin / Reference Measured / Reading Should Be Within Range From 25 / + ("1" Level) / -4.00 to -5.00V 24 / - ("0" Level) / -24.50 to -21.50V
c.	The source impedances are determined by fixed value 1.2K, 2.0K, and 470Ω resistors (A7R13-R15) which are shown in the A7 and A29 circuit diagram, Figure 4.16.
18.	RECORDING OUTPUTS - RECORD COMMANDS "0" State Level: -24.5 to -21.5V. Source Impedance: 5K. "1" State Level: -5 to -1V. Source Impedance: 1K.
a.	Set DY-2401C Power switch to ON, other controls as follows: SAMPLE PERIOD: .01 SEC SAMPLING RATE: FULLY CLOCKWISE 100 KC STD (rear panel): INT
b.	Connect Oscilloscope channels A and B to J2, pins 21 and 22, to verify "0" and "1" state levels. Oscilloscope will display the switching between "0" and "1" state levels as an unbalanced square wave with 20.5 to 29.5v p-p amplitude. Record p-p signal amplitudes.
c.	The "1" state source impedance is determined by fixed value 1K resistors R6 and R7, which are shown in the A17 and A18 circuit diagram, Figure 4.28, connected to pins 11 and 17 of A17. The "0" state source impedance is determined by fixed value 3.9K resistors (A17R18 and A17R21), which are also shown in Figure 4.28.
19.	EXTERNAL PROGRAMMING - HOLD OFF INPUT Hold State: +1 to +12V at 4.5 ma. Non-Hold State: -1 to -35V.

HI Terminal To J2 Pin	Reference Measured	Reading Should Be Within Range From
25	+ ("1" Level)	-4.00 to -5.00V
24	- ("0" Level)	-24.50 to -21.50V

Table 4.3 Cont'd

19. EXTERNAL PROGRAMMING - HOLD OFF INPUT

a. Set DY-2401C Power switch to ON, other controls as follows:

FUNCTION:	VOLT
RANGE:	INT +1V
STORE/DISPLAY (rear panel):	DISPLAY
SAMPLE PERIOD:	.01 SEC
SAMPLING RATE:	FULLY CLOCKWISE

b. Connect positive voltage to J1 pin p (or J2, pin 22), and connect return to J1, pin Z (or J2, pin 50). Very slowly, increase voltage from zero until the DY-2401C stops measuring. Record the hold voltage. Positive voltage to +12V dc should have the same effect.

c. Repeat step b, above, but reverse polarity of voltage. The measurement display cycling of the DY-2401C should not be interrupted by -1V dc to J2, pin 22. This should be true for the range of voltages from -1 to -35V dc. Record minimum negative voltage that does not stop the measurement-display cycle.

20. EXTERNAL PROGRAMMING - FUNCTION INPUT

Input Requirement:	External contact closure to ground or clamp that holds input pin at -1V dc or more positive while supplying 70 ma.
Function W/No Programming:	VOLTS.
Programmable Functions:	FREQ and (with DY-2410B Units Coupling Card A9 installed) Ω, AC Normal, and AC Fast.

a. Set DY-2401C Power switch to ON, other controls as follows:

FUNCTION:	EXT SEL
SAMPLING RATE:	CLOCKWISE FROM STOP
SAMPLE PERIOD:	1 SEC
RANGE:	1V

b. Record lighted DY-2401C units display, which should be VOLTS.

Table 4.3 Cont'd

20. EXTERNAL PROGRAMMING - FUNCTION INPUT (Cont'd)

c. Connect a jumper from J1, pin Z, to each of the following other J1 pins in turn, recording DY-2401C units display lighted at each test.

Jumper J1 Pin Z to Pin	Units Display Readout
B	KC
C	Ω
D	AC Normal
E	AC Fast

21. EXTERNAL PROGRAMMING - RANGE INPUT

Input Requirement: External contact closure to ground or clamp that holds input pin at -1V dc or more positive while supplying 70 ma.

Programmable Ranges: .1, 1, 10, 100, 1000V.
.01V w/DY-2411A Decimal Point Logic Card A30 installed.
10MΩ w/DY-2410B Unit Coupling Card A9 installed.

a. With DY-2401C controls set as for check 20, connect .1V dc across the HI and LO terminals.

b. Connect a jumper from J1, pin Z, to each of the following other J1 pins in turn, recording digital readout at each test.

Jumper J1 Pin Z to Pin(s)	Approximate Digital Readout	Programmed Range
G	100.000MV	0.1V
H	0100.00MV	1. V
J	00.1000V	10. V
K	000.100V	100. V
L	0000.10V	1000. V
With DY-2411A Decimal Logic Card A30 Installed		
G and S	10.0000MV	0.1V and ÷10 Gain
With DY-2410B Units Coupling Card A9 Installed, .1V DC Source Disconnected, HI and LO Terminals Shorted Together		
G and C	000.000Ω	0.1V and Ω

Table 4.3 Cont'd

21. EXTERNAL PROGRAMMING - RANGE INPUT (b, Cont'd)

Jumper J1 Pin Z to Pin(s)	Approximate Digital Readout	Programmed Range
With DY-2410B Units Coupling Card A9 Installed, .1V DC Source Disconnected, HI and LO Terminals Shorted Together		
H and C	0.00000KΩ	1V and Ω
J and C	00.0000KΩ	10V and Ω
K and C	000.000KΩ	100V and Ω
L and C	0000.00KΩ (1MΩ)	1000V and Ω
M	00.0000MΩ (10MΩ)	10MΩ

22. EXTERNAL PROGRAMMING - SAMPLE PERIOD

Input Requirement: External contact closure to ground or clamp that holds input pin at -1V dc or more positive while supplying 70 ma.

Programmable Periods: .01, .1, 1 SEC.

a. With DY-2401C on, set controls as follows:

FUNCTION: VOLT
SAMPLING RATE: CLOCKWISE FROM STOP
SAMPLE PERIOD: EXT SEL
RANGE: INT +1V

b. Connect a jumper from J1, pin Z, to each of the following other J1 pins in turn, recording digital readout at each test.

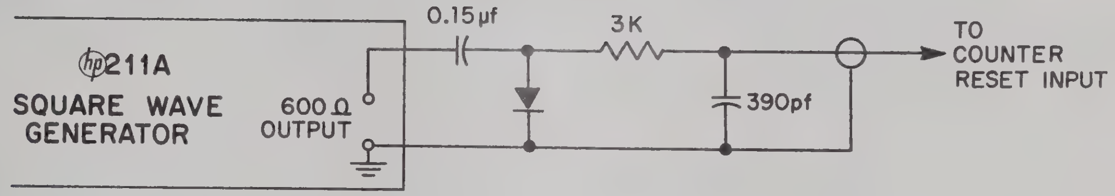
Jumper J1 Pin Z to Pin	Digital Readout	Programmed Sample Period
N	+001.000V	.01 Sec
P	+01.0000V	.1 Sec
R	+1000.00MV	1. Sec

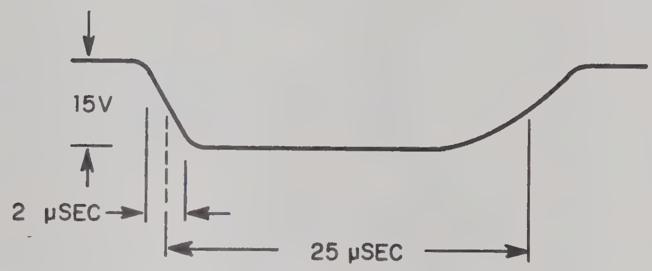
Table 4.3 Cont'd

23.	EXTERNAL PROGRAMMING - SAMPLE PERIOD START/STOP Start/Stop Enabling: By contact closure to ground or clamp that holds input pin at -1V dc or more positive. Sample Period Start: By contact closure to ground or -1 to +5V dc level. Sample Period Stop: By opening contact closure or -5 to -30V dc level.
a.	Set DY-2401C controls as for check 22; set rear panel STORE/ DISPLAY switch to DISPLAY position.
b.	Connect jumpers from J1, pin Z, to pins a and b of J1; record (start) on the test card if counting starts.
c.	Disconnect the jumper from pin b of J1 and record (stop) on the test card if counting stops. Then disconnect jumper from pin a.
24.	EXTERNAL PROGRAMMING - RESET Counter Reset Line: External contact closure to ground or clamp that holds input pin between 0 and -1V dc. Counter Reset Input: Negative 15V, 25 μs pulse with rise time <2 μs to J4 on rear panel.
a.	With DY-2401C on, set controls as follows: FUNCTION: VOLT SAMPLING RATE: STOP SAMPLE PERIOD: 1 SEC RANGE: INT +1V STORE/DISPLAY (rear panel): DISPLAY
b.	Connect a jumper from J1, pin Z, to pin C of J1 and observe DY-2401C digital display. Record yes on test card if counting is triggered for one sample period.
c.	Disconnect jumper. Record no on test card if counting is not triggered.
d.	Connect Square Wave Generator 600Ω output to COUNTER RESET receptacle on rear of DY-2401C through a pulse shaping network as shown on the next page.

Table 4.3 Cont'd

24. EXTERNAL PROGRAMMING - RESET





e. While monitoring output of pulse shaping network with an Oscilloscope, set Square Wave Generator for 15V p-p at 20 kc output frequency. Then set Square Wave Generator for 1 cps output frequency.

f. Set DY-2401C for .01 SEC SAMPLE PERIOD and record a yes on the test card if counting is triggered about once a second.

4.3 AIR FILTER

Inspect the air filter (center of rear panel) regularly and clean it before it becomes dirty enough to restrict air flow. Proceed as follows:

1. Remove filter-housing assembly (unlock the two quarter-turn fasteners and slide housing to the rear).

2. Wash filter in warm water and detergent.

3. Remove cleaning solution from filter-housing assembly by shaking. Allow the assembly to dry completely before securing it to the rear of the instrument.

CAUTION
DO NOT APPLY ANY COATING COMPOUND TO THE FILTER.

4.4 TROUBLESHOOTING

When trouble is suspected it can often be isolated rapidly to a specific assembly or group of assemblies by performing a series of brief checks, such as those diagrammed in Figure 4.2. From start, and before the instrument's cover is removed, the counter is checked, with various aspects of the check results diagrammed as diamond-shaped decision points. The decision point "yes" outputs form a main sequence that leads to and through the voltmeter (VM) full-scale calibration check, the range-overranging-overload check, and the integration check. "No" outputs point leftward toward checks off the main sequence or toward the component(s) that could cause an incorrect check result at the decision point.

After the initial check has isolated the trouble area, remove the instrument cover per section 4.5 to permit completion of troubleshooting and repair. This next stage of troubleshooting may be greatly simplified by substituting for each suspected assembly in turn a spare assembly that is known to be operating correctly. Component assembly locations in the DY-2401C are indexed in Table 4.4 and illustrated in Figures 4.3 through 4.6. When the faulty assembly is found, trouble may then be traced to the defective component, or the faulty assembly may be shipped to your Hewlett-Packard field office for repair.

DY-2401C PERFORMANCE CHECK TEST CARD

SER. ____-____ DATE ________

DESCRIPTION	CHECK RESULTS
1. VOLTAGE MEASUREMENT RANGES	
.1, 1, 10, 100, 1000V readings correct?	☐
.3, 3, 30, 300V readings correct?	☐ (yes)
Reading of overload voltage	☐ VOLTS (308-315v)
2. VOLTAGE MEASUREMENT - INTEGRATION OF POSITIVE AND NEGATIVE VOLTAGES	
Polarity reversal reverses count?	☐
Polarity symbol changes at zero?	☐
Forward counting resumes at zero?	☐ (yes)
3. INTERNAL TIME BASE	100 KC STD (J3)
Frequency offset from 100 kc:	
At start of test*	☐ parts in 10^6
1 week later*	☐ parts in 10^6
Aging rate difference*	☐ parts in 10^6 ($< \pm 2$ parts in 10^6)
*At 25 ±5°C ambient temperature.	

Note: Because considerable time and a precisely-controlled temperature chamber are required, it is anticipated that few users of the DY-2401C will check the effects of temperature upon the time base, the internal calibration standard, and voltage measurements. For this reason, no spaces are provided for entering temperature test results in any of the checks. However, procedures are presented in Table 4.3 of the handbook for those users who desire to check the effect of temperature upon the performance of the instrument.

SER. ____-____ DATE ________

DESCRIPTION	CHECK RESULTS
4. INTERNAL CALIBRATION SOURCE	
Voltage:	
At start of test	______ MV
1 month later	______ MV
2 months later	______ MV
3 months later	______ MV
4 months later	______ MV
5 months later	______ MV
6 months later	______ MV (1000 ±0.82 mv)*

*At 25°C ambient; quoted tolerance includes potential inaccuracy (±0.001%) of external standard.

DESCRIPTION	CHECK RESULTS
5. VOLTAGE MEASUREMENT - FULL SCALE ACCURACY	
Input Measured:*	
-1 volt	______ MV (-1000 ±0.17 mv)*
+1 volt	______ MV (+1000 ±0.17 mv)*
0.99108 volt	______ MV (+099.108 ±0.18 mv)*
10 volts	______ VOLTS (+10 ±0.0018v)*
100 volts	______ VOLTS (+100 ±0.018v)*
1000 volts	______ VOLTS (+1000 ±0.18v)*

*At 25°C ambient; the quoted tolerance includes potential inaccuracy (±0.001% for 1v, ±0.002% for other voltages) of external standard.

SER. ____-____ DATE ________

DESCRIPTION		CHECK RESULTS
6. VOLTAGE MEASUREMENT - LINEARITY		
Input Measured:*	Range:	
+3 volts	1 volt	______ MV (+3000 ±0.82 mv)*
-3 volts	1 volt	______ MV (-3000 ±0.82 mv)*
-2 volts	1 volt	______ MV (-2000 ±0.45 mv)*
+2 volts	1 volt	______ MV (+2000 ±0.45 mv)*
+900 volts	1000 volts	______ VOLTS (+900 ±0.17v)*
+800 volts	1000 volts	______ VOLTS (+800 ±0.16v)*
+700 volts	1000 volts	______ VOLTS (+700 ±0.14v)*
+600 volts	1000 volts	______ VOLTS (+600 ±0.13v)*
+500 volts	1000 volts	______ VOLTS (+500 ±0.12v)*
+400 volts	1000 volts	______ VOLTS (+400 ±0.11v)*
+300 volts	1000 volts	______ VOLTS (+300 ±0.10v)*
+200 volts	1000 volts	______ VOLTS (+200 ±0.08v)*
+100 volts	1000 volts	______ VOLTS (+100 ±0.07v)*

*At 25°C ambient; quoted tolerance includes potential inaccuracy (±0.002%) of external standard.

7. VOLTAGE MEASUREMENT - REJECTION OF COMMON MODE NOISE

DESCRIPTION	CHECK RESULTS
Reading of 1.5V input without noise	______ MV

SER. ____-____ DATE ________

DESCRIPTION	CHECK RESULTS
7. VOLTAGE MEASUREMENT - REJECTION OF COMMON MODE NOISE (Cont'd)	
AC common mode signal required to change reading more than ±2 digits:	
1.0 sec sample period	[ ] v rms
0.1 sec sample period	[ ] v rms
.01 sec sample period	[ ] v rms (>100v rms)
8. VOLTAGE MEASUREMENT - REJECTION OF SUPERIMPOSED NOISE	
55 cps signal required to affect 10 MV digit*	[ ] mv rms (>100 mv rms)
550 cps signal required to affect 10 MV digit*	[ ] v rms (>1v rms)
*10 volt range, 0.1 sec sample period.	
9. FREQUENCY MEASUREMENT RANGE	
Lowest frequency of the range	[ ] KC (<000.005 kc)
Highest frequency of the range	[ ] KC (>300.000 kc-STD) (>1200.000 kc-M29)
10. FREQUENCY MEASUREMENT - SENSITIVITY	
Minimum signal amplitude required for triggering at high end (300 kc or 1200 kc*)	[ ] v rms (0.1v rms, max., 300 kc) (0.5v rms, max., 1200 kc*)
(*) DY-2401C-M29.	

SER. ____-____ DATE ________

DESCRIPTION	CHECK RESULTS
10. FREQUENCY MEASUREMENT - SENSITIVITY (Cont'd)	
Minimum pulse amplitude required for triggering at 1 kc (duration constant at 2 μsec)	[ ] v peak (-1v, max.)
Minimum pulse duration required for triggering at 1 kc (amplitude constant at -1v peak)	[ ] μs (2 μs, max.)
11. RESPONSE TIME AND MEASUREMENT SPEED	
	PROGRAM CONTROL (J1, Pin d) BCD OUTPUT (J2, Pin 23)
Reading of steady 20V input	[ ] VOLTS
Difference between reading of steady input and reading from step input of the same voltage	[ ] VOLTS (±0.0002v, max.)
Response time from reset to start of measurement	[ ] ms (9.67 ±0.02 ms)
Total measurement times:	
.01 sec sample period	[ ] ms (19.67 ±0.02 ms)
0.1 sec sample period	[ ] ms (109.67 ±0.02 ms)
1.0 sec sample period	[ ] ms (1009.67 ±0.02 ms)
12. TIME BASE OUTPUT (Rear Panel)	100 KC STD (J3)
Amplitude	[ ] v p-p (1.25 ±0.1v p-p)

SER. ____-____ DATE ________

DESCRIPTION	CHECK RESULTS
13. TIME BASE EXTERNAL INPUT (Rear Panel)	100 KC STD (J3)
Minimum amplitude required for reliable time base triggering	[ ] v p-p (2v p-p, max.)
14. RECORDING OUTPUTS - BCD DATA	BCD OUTPUT (J2)

Decade:	Outputs correct at J2 pins					
10^0 (A11)	3	4	28	29	?	[ ]
10^1 (A12)	5	6	30	31	?	[ ]
10^2 (A13)	7	8	32	33	?	[ ]
10^3 (A14)	9	10	34	35	?	[ ]
10^4 (A15)	11	12	36	37	?	[ ]
10^5 (A46)	13	14	38	39	?	[ ]
						(yes)

15. RECORDING OUTPUTS - BCD FUNCTION

Function:	Outputs correct at J2 pins					
	41	40	16	15		
+VDC	0	0	0	1	?	[ ]
-VDC	0	0	1	0	?	[ ]
KC	0	0	1	1	?	[ ]
KΩ	0	1	1	0	?	[ ]
MΩ	0	1	1	1	?	[ ]
OVERLOAD	1	1	1	1	?	[ ]
VAC	1	0	0	1	?	[ ]
						(yes)

16. RECORDING OUTPUTS - BCD DECIMAL POINT

Display:	Outputs correct at J2 pins					
	27	26	2	1		
000000. V	0	0	0	0	?	[ ]
00000.0 V	0	0	0	1	?	[ ]
						(yes)

Note: "0" = -35 to -24.5V DC
"1" = -2.5 to 0V DC

SER. ____-____ DATE ________

DESCRIPTION	CHECK RESULTS

16. RECORDING OUTPUTS - BCD DECIMAL POINT (Cont'd)

BCD OUTPUT (J2)

Display:	Outputs correct at J2 pins 27	26	2	1		
0000.00 V	0	0	1	0	?	☐
000.000 V	0	0	1	1	?	☐
00.0000 V	0	1	1	0	?	☐
0000.00 MV	0	1	1	1	?	☐
000.000 MV	1	1	0	0	?	☐
00.0000 MV	1	1	0	1	?	☐

(yes)

Note: "0" = -35 to -24.5V DC;
"1" = -2.5 to 0V DC

17. RECORDING OUTPUTS - REFERENCE LEVELS

"1" state reference at J2, pin 25 — ☐ v dc (-24.5 to -21.5v dc)

"0" state reference at J2, pin 24 — ☐ v dc (-5 to -4v dc)

18. RECORDING OUTPUTS - RECORD COMMANDS

-Record amplitude at J2, pin 21 — ☐ v p-p
+Record amplitude at J2, pin 23 — ☐ v p-p
(20.5 to 29.5v p-p)

19. EXTERNAL PROGRAMMING - HOLDOFF INPUT

PROGRAM CONTROL (J1, Pin p) or BCD OUTPUT (J2, Pin 22)

Minimum positive hold voltage — ☐ v dc (+1v, max.)

Minimum negative non-hold voltage — ☐ v dc (-1v, max.)

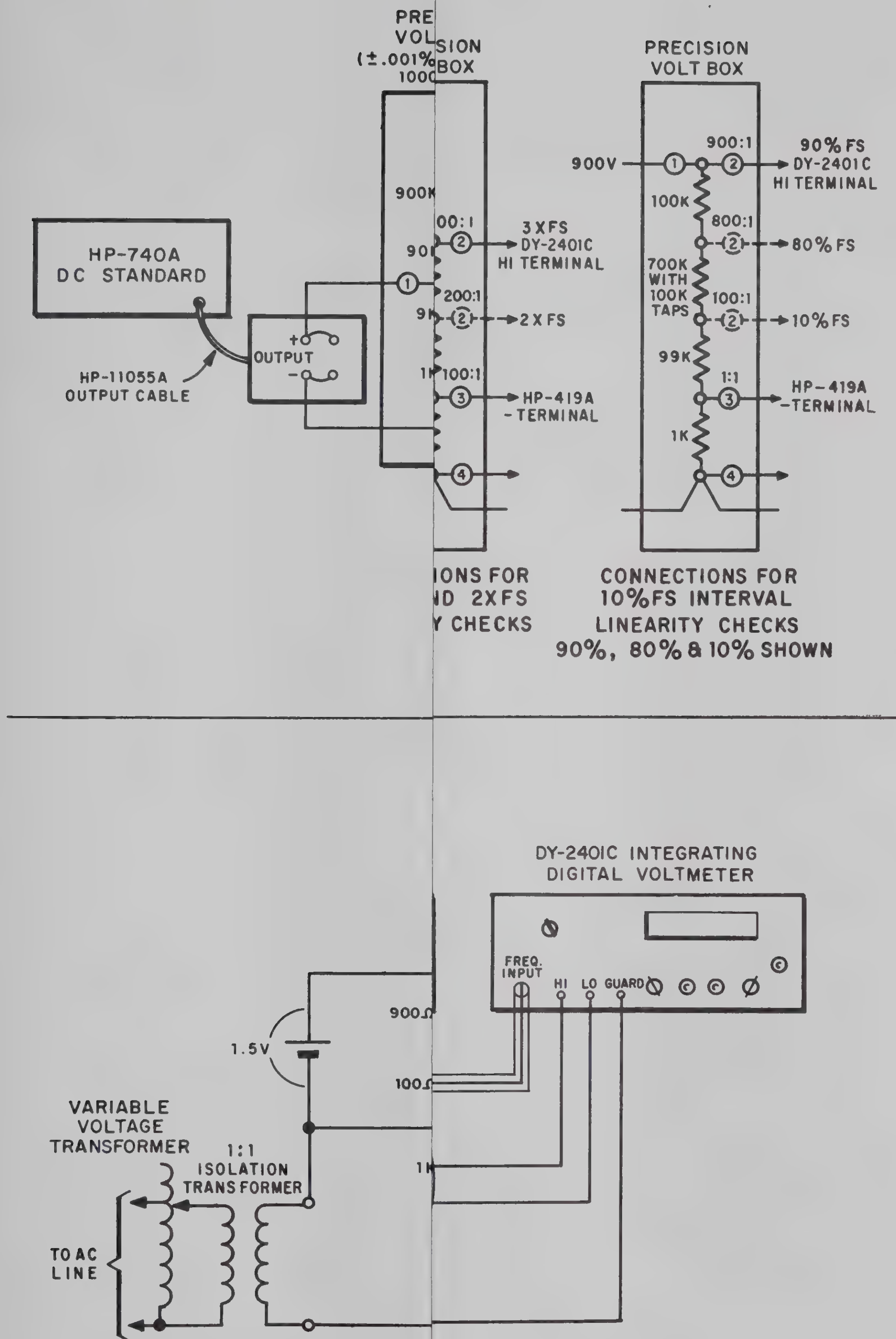
SER. ____-____ DATE ________

DESCRIPTION			CHECK RESULTS
20. EXTERNAL PROGRAMMING - FUNCTION INPUT			PROGRAM CONTROL (J1)
J1 pin Z connected to pin:	Prog. function:		Units Readout
None	Volts DC		☐ VOLTS
B	Frequency		☐ KC
C	Ohms		☐ Ω
D	Volts AC		☐ AC VOLTS
E	Volts AC		☐ AC VOLTS
21. EXTERNAL PROGRAMMING - RANGE INPUT			PROGRAM CONTROL (J1)
J1 pin Z connected to pin:	Prog. range:	Approx. digital readout	
G	.1 volt	100.000 MV ?	☐
H	1 volt	0100.00 MV ?	☐
J	10 volt	00.1000 V ?	☐
K	100 volt	000.100 V ?	☐
L	1000 volt	0000.10 V ?	☐
G, S	.01 volt	10.0000 MV ?	☐
G, C	100 ohm	000.000 Ω ?	☐
H, C	1 kilohm	0.00000 KΩ ?	☐
J, C	10 kilohm	00.0000 KΩ ?	☐
K, C	100 kilohm	000.000 KΩ ?	☐
L, C	1000 kilohm	0000.00 KΩ ?	☐
M	10 megohm	00.0000 MΩ ?	☐
			(yes)
22. EXTERNAL PROGRAMMING -SAMPLE PERIOD			PROGRAM CONTROL (J1)
J1 pin Z connected to pin:	Prog. sample period:	Digital readout	
N	.01 sec	+001.000V ?	☐
P	0.1 sec	+01.0000V ?	☐
R	1.0 sec	+1000.00MV ?	☐
			(yes)

DY-2401C PERFORMANCE CHECK TEST CARD

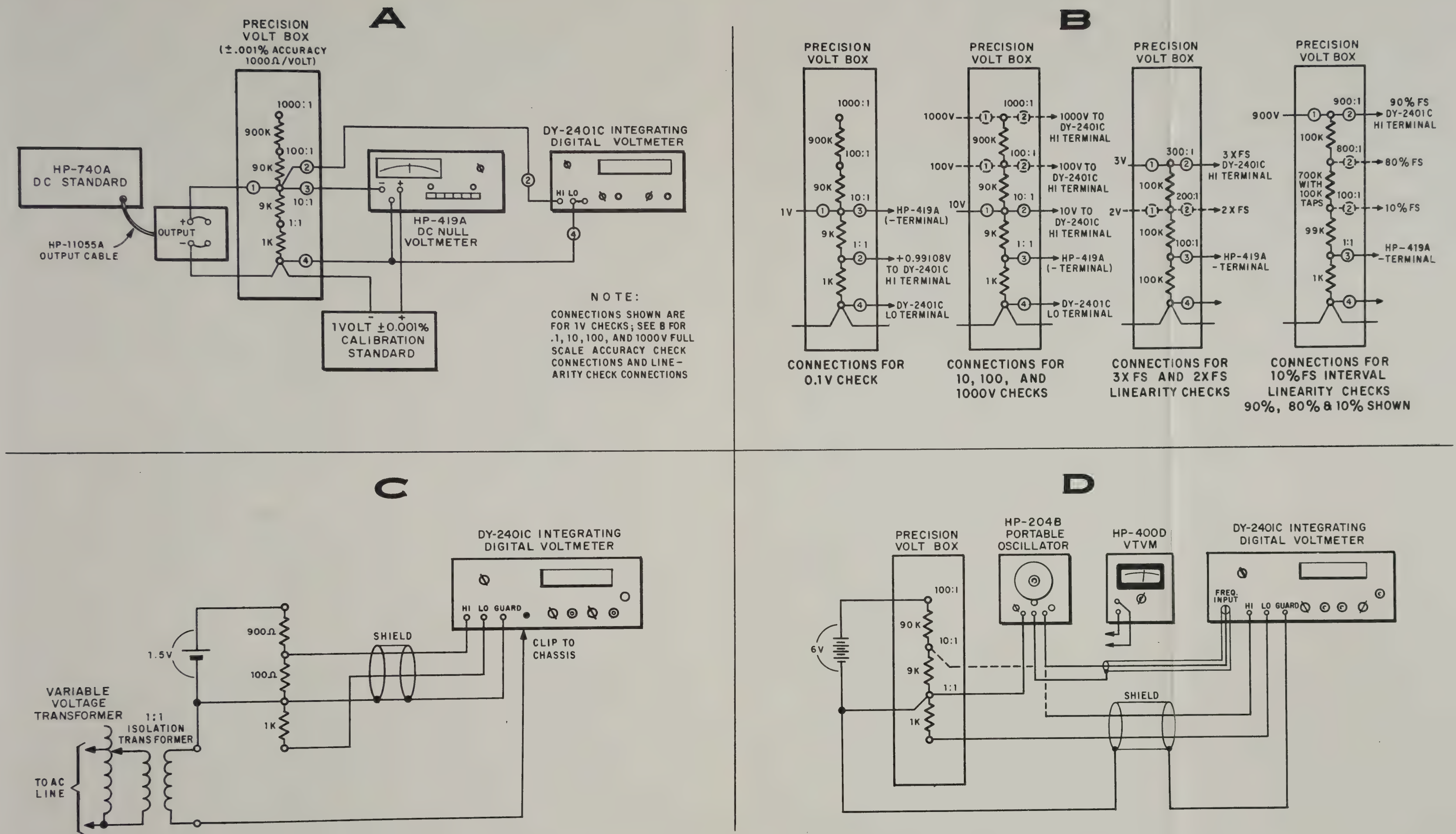
SER. ____-____ DATE ________

DESCRIPTION		CHECK RESULTS
23. EXTERNAL PROGRAMMING START/STOP		PROGRAM CONTROL (J1)
J1 pin Z connected to pin:	Measurement:	
a, b	Starts?	☐
a only	Stops ?	☐ (yes)
24. EXTERNAL PROGRAMMING - RESET		PROGRAM CONTROL (J1) COUNTER RESET (J4)
J1 pin Z connected to pin:		
c	Measurement triggered ?	☐ (yes)
None	Measurement triggered ?	☐ (no)
-15V, 25 μsec pulse w/rise time <2 μsec triggers measurement?		☐ (yes)

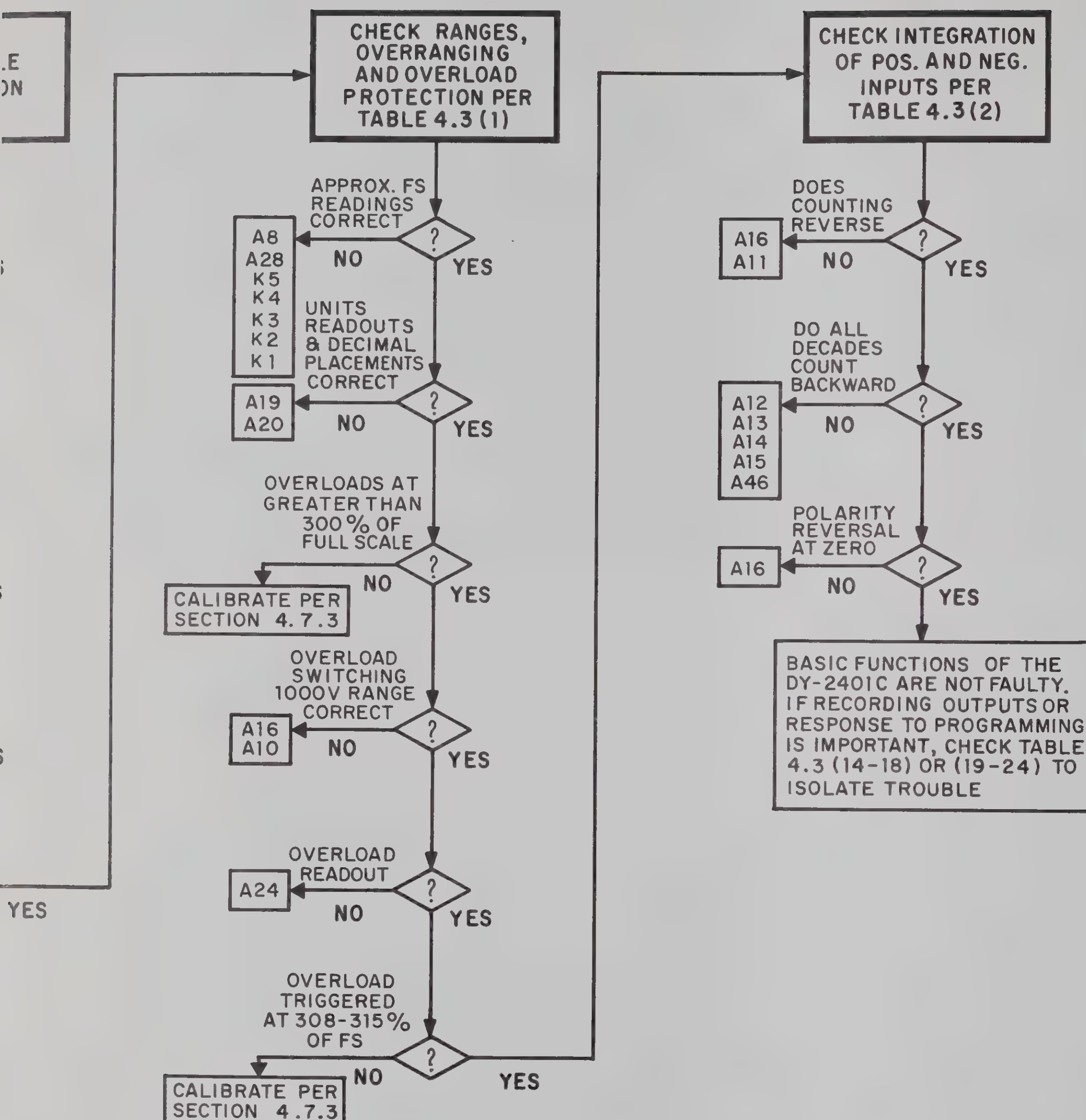


PERFORMANCE CHECK SETUPS

FIGURE 4.1



PERFORMANCE CHECK SETUPS
FIGURE 4.1



TROUBLESHOOTING

FIGURE 4.2

If spare assemblies are not available for troubleshooting by substitution, the trouble must be pinpointed by signal tracing with oscilloscope and voltmeter. This procedure is also used to locate defective components on a faulty assembly. The DY-2401C overall logic diagram, Figures 4.10A, B, and C, is provided to assist the signal tracing process. Equally useful are the detailed parts placement illustrations, circuit diagrams, and circuit descriptions for each assembly that are indexed in Table 4.4, with the assembly locations. For easy access to assembly circuits during operation, use the printed circuit assembly extension cards provided with each instrument.

4.5 INSTRUMENT COVER REMOVAL AND ACCESS TO ASSEMBLIES

To remove the top wraparound cover, unscrew the six screws from the lower right and lower left sides of the instrument. The top cover may then be lifted from the instrument.

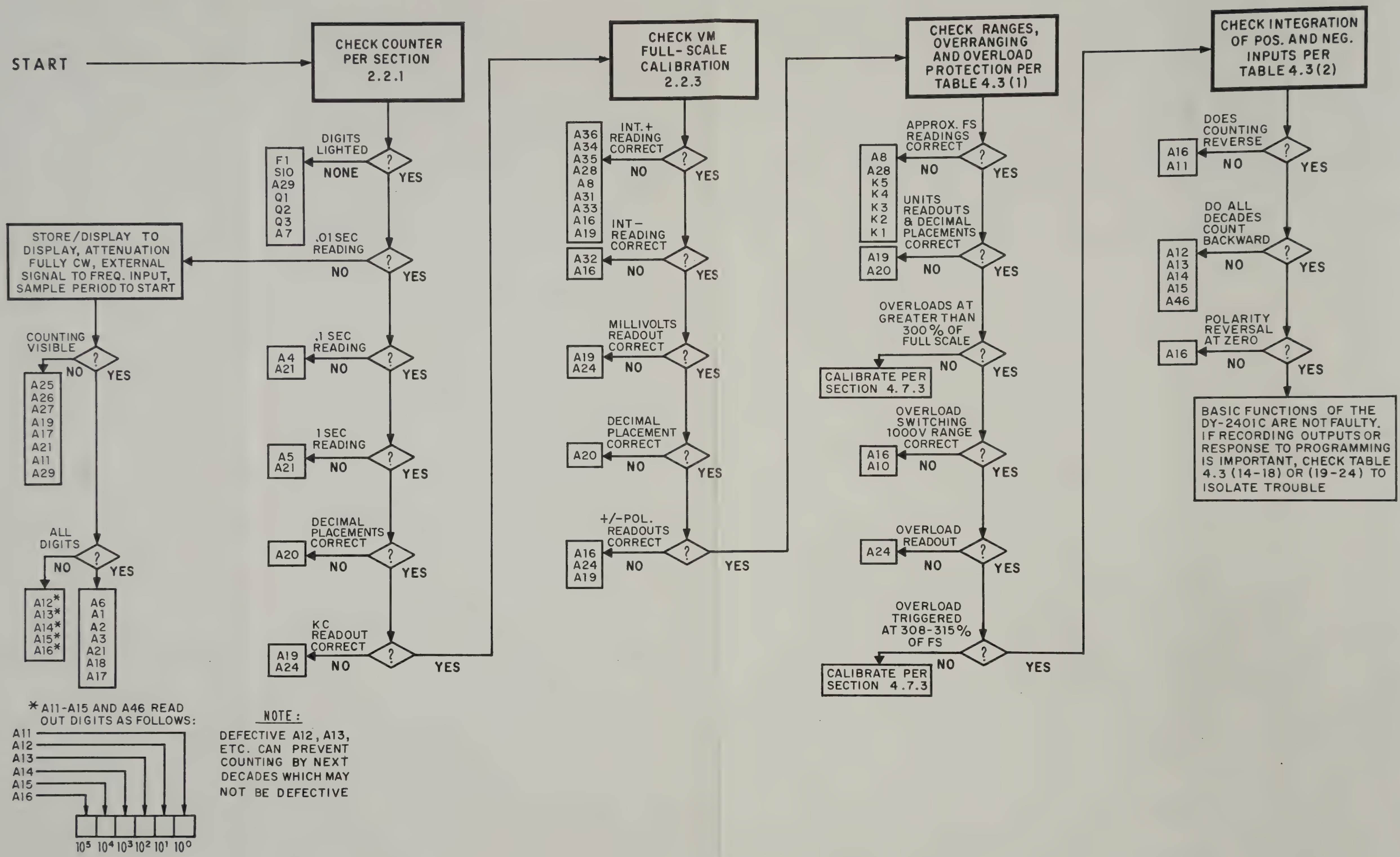
WARNING

DISCONNECT ANY HIGH POTENTIAL (50 TO 500 VOLTS) FROM THE HIGH, LO, AND GUARD TERMINALS TO ELIMINATE SHOCK HAZARD AT THE V-F CONVERTER CHASSIS AND SHIELD PLATES.

Remove the upper shield plate from the v-f converter by pulling up on the white plastic fasteners. All components shown in Figure 4.3 should now be visible. For access to components shown in Figure 4.4, pull up on white plastic fasteners at corners of integrating amplifier card rack.

With the instrument upside down, unscrew the seven attaching screws and remove the bottom cover. The lower v-f converter shield plate is removed in the same manner as the upper shield. Remove both attaching screws and the cover shield for access to the precision resistors in A28. These operations gain access to the components shown in Figure 4.5. For access to the components shown in Figure 4.6, release the swing chassis fasteners and open the swing chassis.

When replacing plug-in printed circuit assemblies and other components, make certain they are installed in the correct place. Reverse the procedure used to gain access to assemblies when troubleshooting, repair, and calibration of the DY-2401C are completed.



TROUBLESHOOTING

FIGURE 4.2

If spare assemblies are not available for troubleshooting by substitution, the trouble must be pinpointed by signal tracing with oscilloscope and voltmeter. This procedure is also used to locate defective components on a faulty assembly. The DY-2401C overall logic diagram, Figures 4.10A, B, and C, is provided to assist the signal tracing process. Equally useful are the detailed parts placement illustrations, circuit diagrams, and circuit descriptions for each assembly that are indexed in Table 4.4, with the assembly locations. For easy access to assembly circuits during operation, use the printed circuit assembly extension cards provided with each instrument.

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With the instrument upside down, unscrew the seven attaching screws and remove the bottom cover. The lower v-f converter shield plate is removed in the same manner as the upper shield. Remove both attaching screws and the cover shield for access to the precision resistors in A28. These operations gain access to the components shown in Figure 4.5. For access to the components shown in Figure 4.6, release the swing chassis fasteners and open the swing chassis.

When replacing plug-in printed circuit assemblies and other components, make certain they are installed in the correct place. Reverse the procedure used to gain access to assemblies when troubleshooting, repair, and calibration of the DY-2401C are completed.

Table 4.4 Component Location and Theory Index

Reference Designation(s)	Component Name or Purpose	For Location(s) See Figure	For Details See Figure(s)	For Circui Descriptior See Section	Pa
A1-A5	Decade Divider Assembly	4.3	4.11, 4.12	3.8	3-1
A6	100KC Oscillator and Schmitt Trigger Assembly	4.3	4.13, 4.14	3.7	3-1
A7	-35V Regulator and Reset Assembly	4.3	4.15, 4.16	3.17	3-2
A8	Attenuator Coupling Logic Assembly	4.3	4.17, 4.18	3.5.1	3-13
A9*	DY-2410B Units Coupling Card	4.3	4.19, 4.20	3.16	3-26
A10	Overload Detector Assembly	4.3	4.21, 4.22	3.4	3-11
A11-A15, A46	Reversible 4-2'-2-1 Decade Counter Assembly	4.3	4.23, 4.24	3.10	3-18
A16	Counter Control Assembly	4.3	4.25, 4.26	3.3	3-9
A17	Gate Control Assembly	4.3	4.27, 4.28	3.6	3-14
A18	Display Control	4.3	4.27, 4.28	3.6	3-14
A19	Units/Counter Input Logic Assembly	4.5	4.29, 4.30	3.11	3-21
A20	Decimal Point Logic Assembly	4.5	4.31, 4.32	3.12.1	3-22
A21	Blanking Logic/ Time Base Selection Assembly	4.5	4.33, 4.34	3.13	3-24

*Supplied with DY-2410B AC/Ohms Converter

Table 4.4 Component Location and Theory Index (Cont'd)

Reference Designation(s)	Component Name or Purpose	For Location(s) See Figure	For Details See Figure(s)	For Circuit Description See Section	Page
A22	Printer Coupling Logic Assembly	4.5	4.35, 4.36	3.14	3-25
A23*	DY-2410B AC & Ohms Delay Gate Card	4.5	4.37, 4.38	3.15	3-25
A24	Units Indicator Assembly	4.3	4.39, 4.40		
A25	Sensitivity (ATTENUATION) Control Assembly	4.5	4.42	3.9	3-18
A26	Input Amplifier Assembly	4.3	4.41, 4.42	3.9	3-18
A27	Trigger Circuit Assembly	4.3	4.41, 4.42	3.9	3-18
A28	Attenuator Assembly	4.5	4.7, 4.44	3.2.1	3-4
A29	+6V Bias Circuit Assembly	4.3	4.15, 4.16	3.17.3	3-28
A30**	DY-2411A Decimal Point Logic Card	4.5	4.47, 4.48	3.12.2	3-23
A31	Integrating Operational Amplifier Assembly	4.3	4.45, 4.46	3.2.2	3-4
A32	Negative Trigger Level Detector Assembly	4.5	4.43, 4.44	3.2.3	3-8
A33	Positive Trigger Level Detector Assembly	4.5	4.43, 4.44	3.2.3	3-8
A34	Series Regulator Assembly	4.3	4.49, 4.50	3.18.2	3-29

*Supplied with DY-2410B AC/Ohms Converter

**Supplied with DY-2411A Guarded Data Amplifier (a jumper board is installed in the A30 position if the DY-2401C is ordered by itself)

Table 4.4 Component Location and Theory Index (Cont'd)

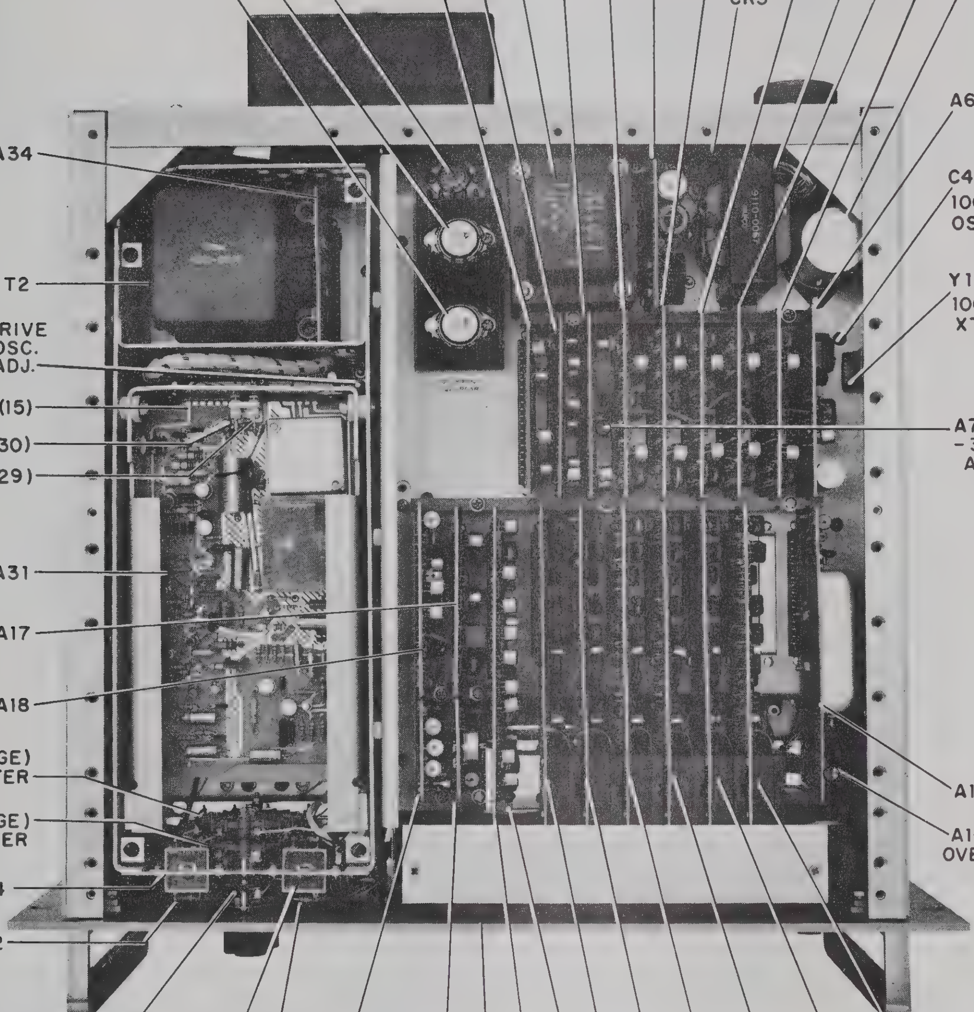
Reference Designation(s)	Component Name or Purpose	For Location(s) See Figure	For Details See Figure(s)	For Circuit Description See Section	Page
A35	Calibration Standard & Power Supply Amplifier Assembly	4.4	4.49, 4.50	3.18.3	3-29
A36	Filter Board	4.5	4.49, 4.50	3.18.1	3-29
A47	1V Relay Timing Assembly	4.6	4.17, 4.18	3.5.2	3-14
C1	+150V filter capacitor	4.6	4.16		
C2	Filtering at input to -35V series regulators	4.3	4.16		
C3	Counter trigger differentiating capacitor	4.6	4.30		
C4	100 KC oscillator trimmer capacitor	4.6	4.14		
C5	100 KC oscillator padder capacitor	4.6	4.14		
C10	-35V regulator output filter	4.6	4.16		
C32, C34	+ and -12.3V regulator output filter capacitors	4.4	4.50		
CR101, CR103-CR105	Attenuator relay surge suppression diodes	4.6	4.18		

Table 4.4 Component Location and Theory Index (Cont'd)

Reference Designation(s)	Component Name or Purpose	For Location(s) See Figure	For Details See Figure(s)	For Circuit Description See Section Page
C202	Coupling capacitor for reset triggered measurement display cycle	4.5	4.28	
K1-K5	Attenuator control relays	4.6	4.18, 4.44	
L1	-35V supply filter inductor	4.3	4.16	
P1/FL1	AC line input receptacle and noise filter	4.6	4.16	
Q1-Q3	-35V supply series regulator transistors	4.3	4.16	
R1	Current limiting resistor	4.6	4.16	
R2	-35V rectifier-filter output load resistor	4.6	4.16	
R3	Series regulator Q3 emitter load resistor	4.6	4.16	
R4	10 kc check attenuator resistor	4.6	4.42	
R5	Capacitor C1 discharge resistor	4.6	4.16	
R6, R7	- and + record command source resistors	4.6	4.28	

Table 4.4 Component Location and Theory Index (Cont'd)

Reference Designation(s)	Component Name or Purpose	For Location(s) See Figure	For Details See Figure(s)	For Circuit Descriptions See Section Page
R8, R9	Counter trigger differentiating resistors	4.6	4.30	
R48	Attenuator resistor, .1V range	4.4	4.44	
R49	Part of cal+ and zero divider network	4.5	4.44	
R50	Part of cal+ and zero divider network	4.4	4.44	
R61, R62	Pos. and neg. channel output transformer (T5 & T4) load resistors	4.3	4.44	
R101, R102, R105-R107	Attenuator relay delay resistors	4.6	4.18	
R202-R204	SAMPLE RATE control network resistors	4.5	4.28	
S1	RANGE switch	4.3	4.18, 4.44	
S2	FUNCTION switch	4.5	4.18, 4.30, 4.32	
S3	SAMPLE PERIOD switch	4.5	4.28, 4.30, 4.34	
S5	SAMPLING RATE switch	4.5	4.28	
T4, T5	Neg. and pos. channel output transformers	4.3	4.44	

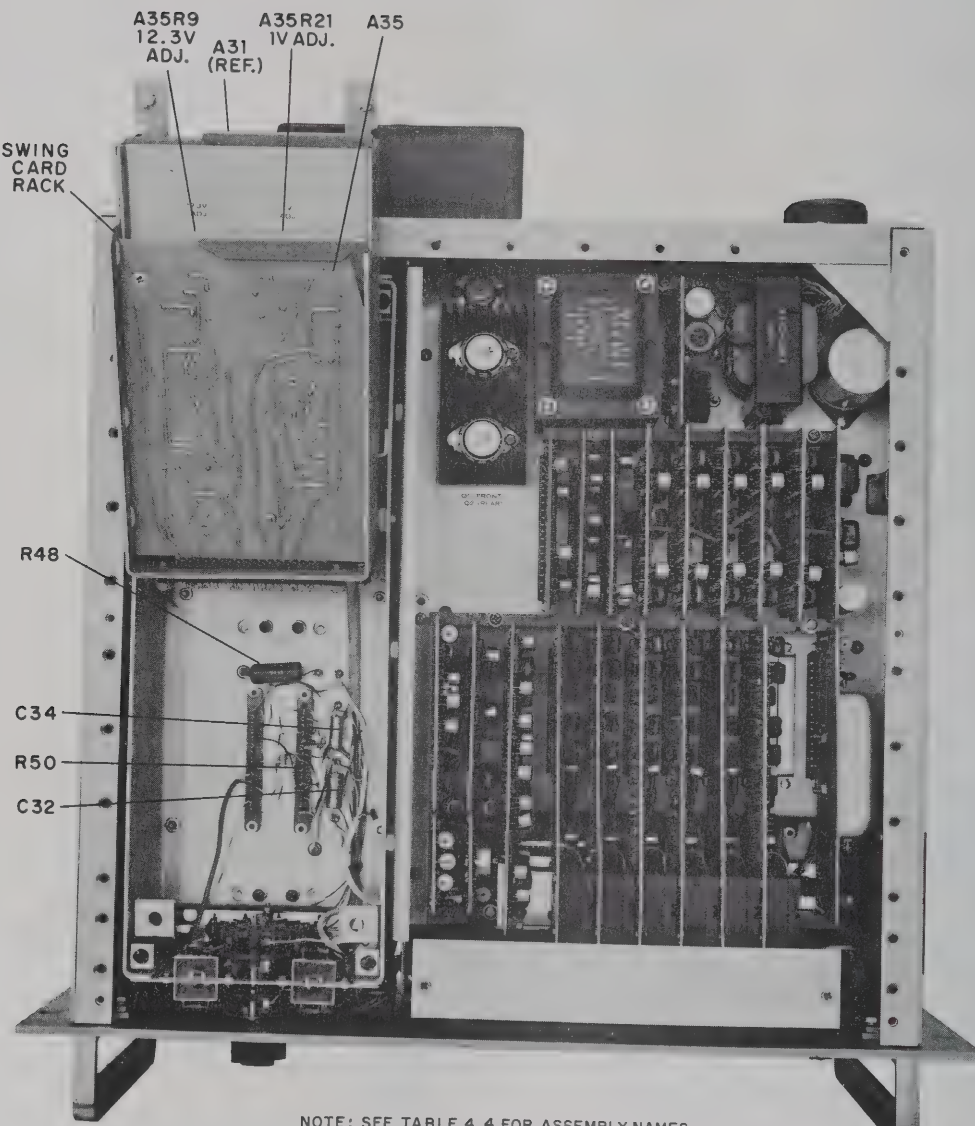


NOTE: SEE TABLE 4.4 FOR ASSEMBLY NAMES OR PURPOSE OF COMPONENTS

* SUPPLIED WITH DY-2410B AC/OHMS CONVERTER

TOP INTERNAL VIEW A

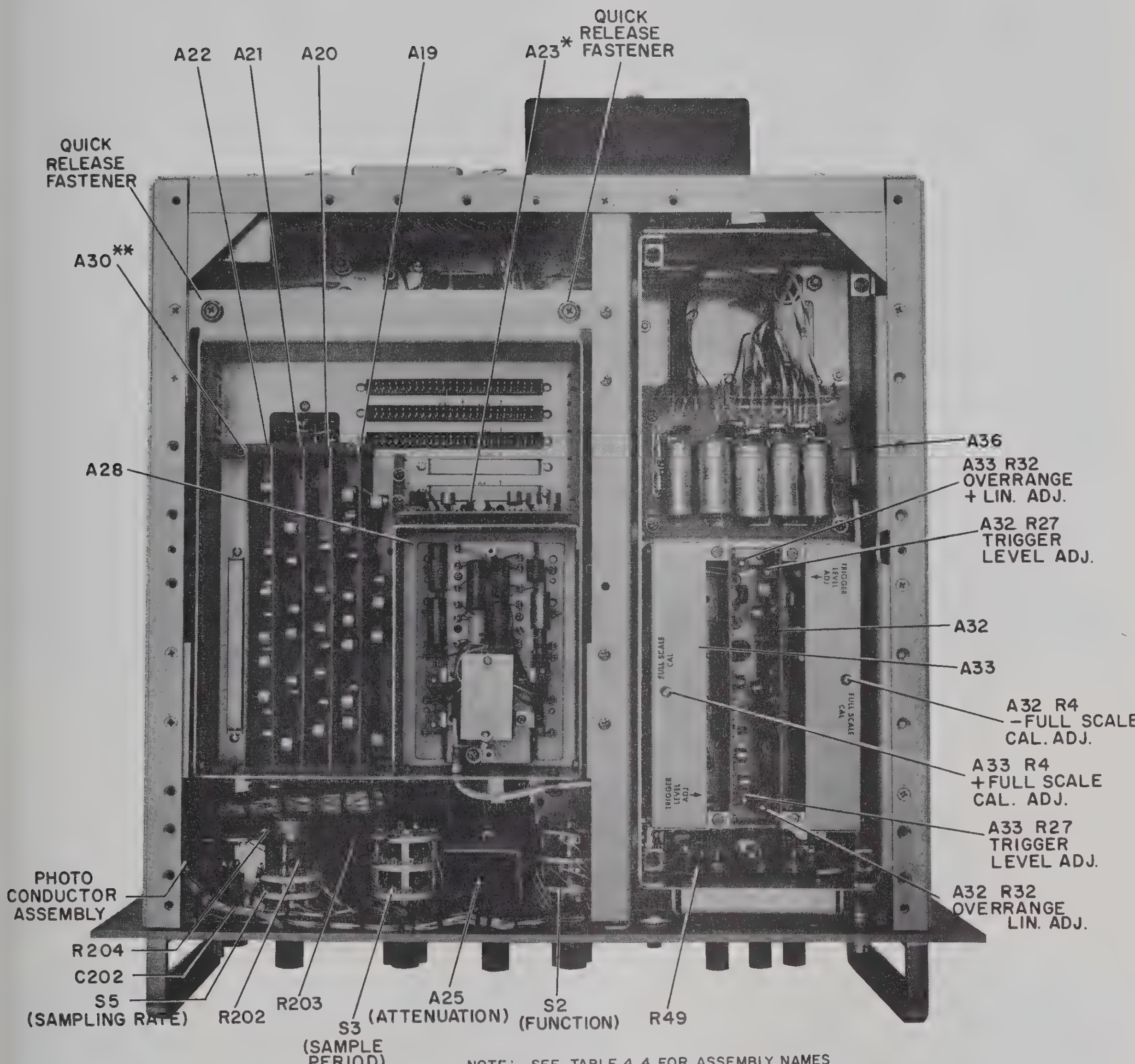
FIGURE 4.3



NOTE: SEE TABLE 4.4 FOR ASSEMBLY NAMES
OR PURPOSE OF COMPONENTS

TOP INTERNAL VIEW B

FIGURE 4.4



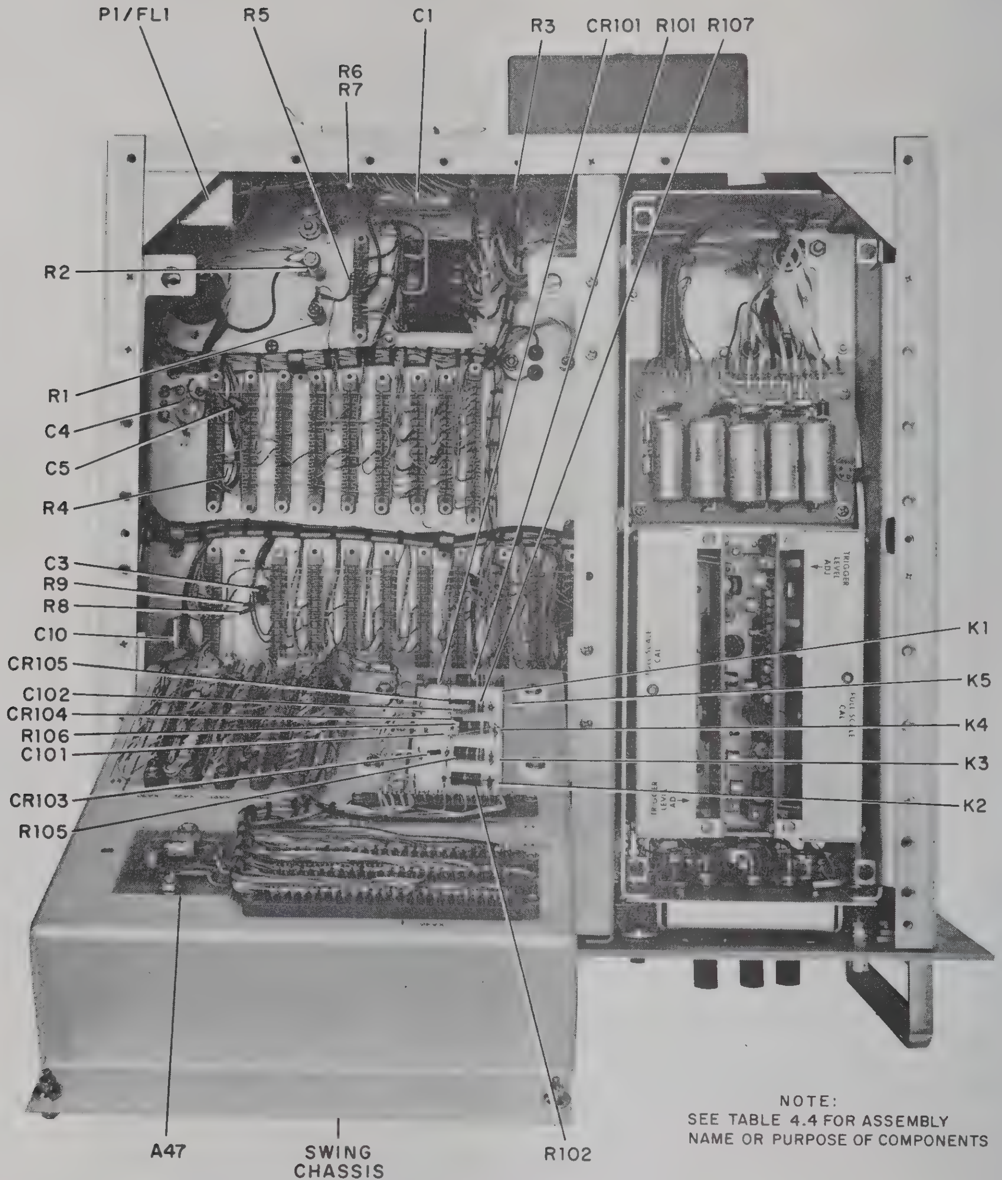
NOTE: SEE TABLE 4.4 FOR ASSEMBLY NAMES OR PURPOSE OF COMPONENTS

* SUPPLIED WITH DY-2410B AC/OHMS CONVERTER

** SUPPLIED WITH DY-2411A GUARDED DATA AMPLIFIER (A JUMPER BOARD IS INSTALLED HERE IF DY-2401C IS ORDERED BY ITSELF.)

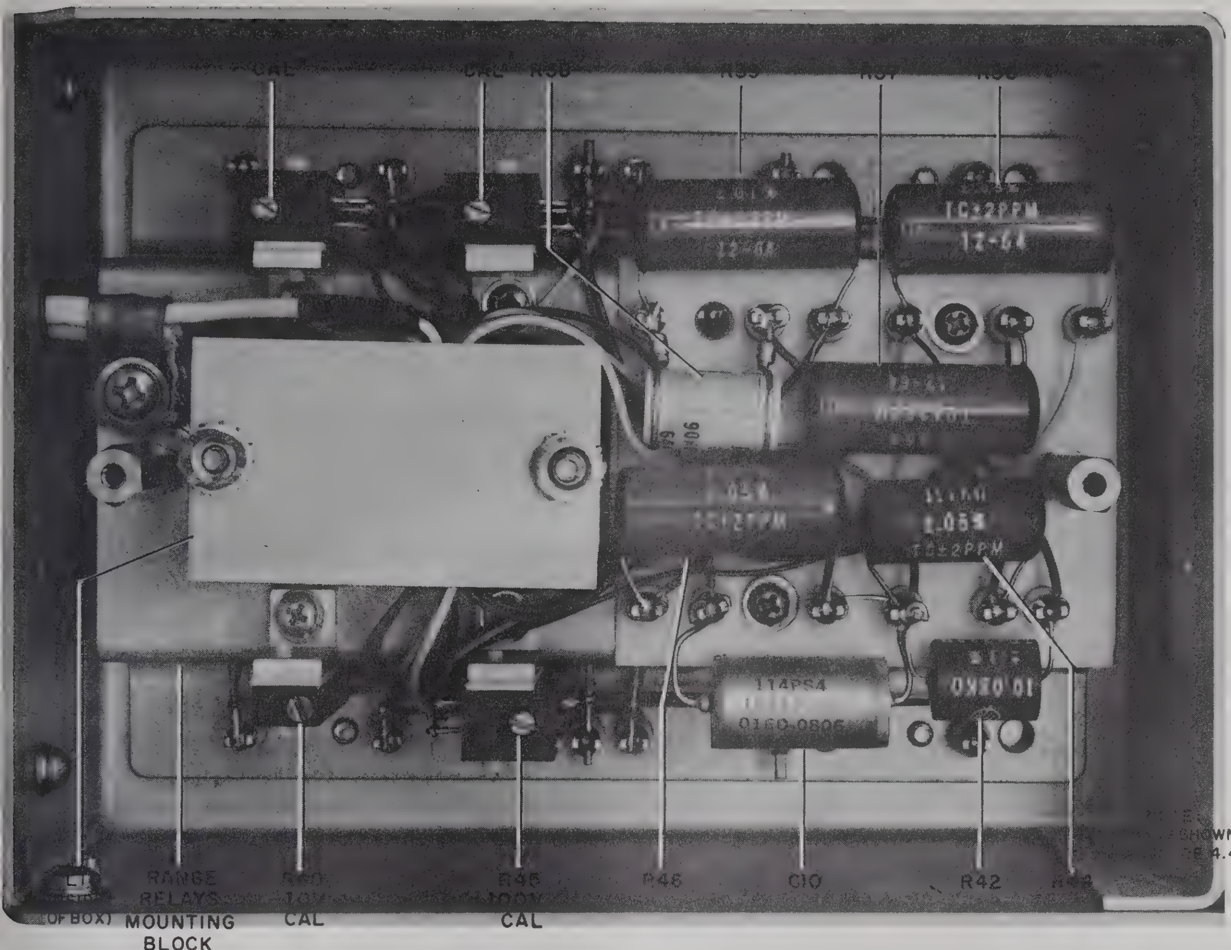
BOTTOM INTERNAL VIEW A

FIGURE 4.5



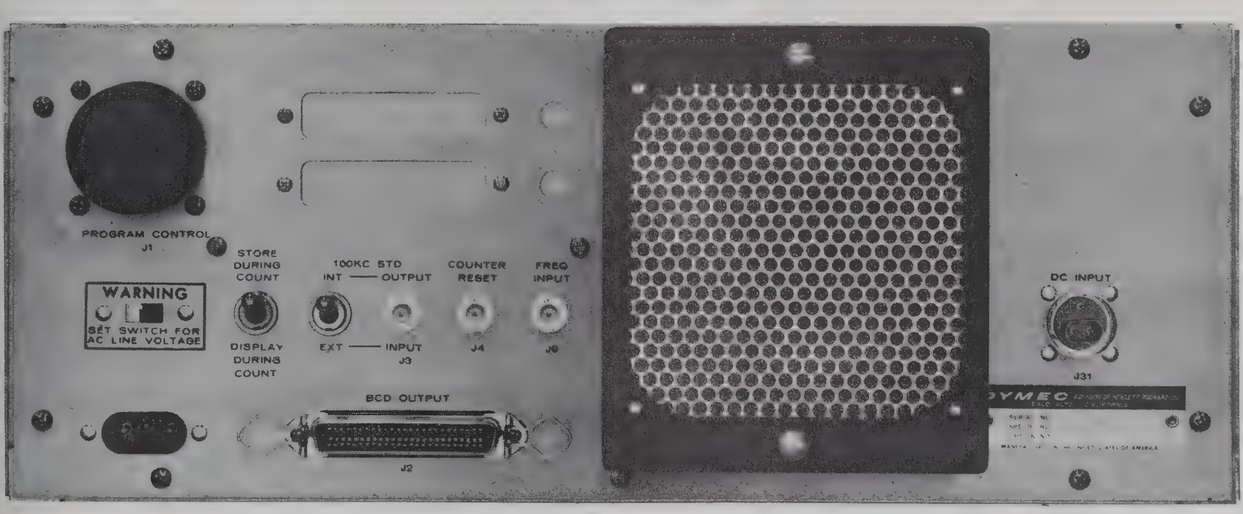
BOTTOM INTERNAL VIEW B

FIGURE 4.6



ATTENUATOR ASSEMBLY (A28)

FIGURE 4.7



REAR PANEL VIEW

FIGURE 4.8

4.6 REPAIR

4.6.1 Assemblies That Should Not Be Repaired in the Field

Satisfactory repair of certain assemblies is difficult to achieve without special training and/or special equipment. Consequently, it is recommended that these assemblies be returned to your Hewlett-Packard field office for repair. The assemblies which should receive this treatment are as follows:

1. Integrating operational amplifier A31.

2. Trigger Level Detector A32 or A33 if R1, R2, R5, R6, or T1 must be replaced.

3. Reversible Decade Counter Assembly (A11-A15 or A46) if photoconductor plate V1 must be replaced.

4.6.2 Replacement of Components on Printed Circuit Assemblies

Component lead holes in the printed circuit boards have plated walls to assure good electrical contact on the opposite sides of the board. Apply heat sparingly and work carefully to avoid damage to this plating. The following replacement procedure is recommended.

a. Remove defective component.

b. Melt solder in component lead holes, using clean dry soldering iron to remove excess solder. Clean holes with a toothpick or wooden splinter. Do not use a metal tool for cleaning because it may damage the through-hole plating.

c. Shape leads of new component to match those of component being replaced and insert leads into the lead holes. Make certain diodes and capacitors are oriented correctly, then solder the component in place, using heat and solder sparingly.

NOTE

Use a heat sink (long-nose pliers or commercial heat sink tweezers) to minimize heat reaching diodes or transistors while their leads are being soldered.

d. Repair any breaks in through-hole plating (indicated by separation of the round conductor pad on either side of the board) by pressing the conductor pads against the board and soldering component lead to pads on both sides of the board.

4.7 CALIBRATION

For normal day-to-day operation of the DY-2401C only the zero and full-scale calibration adjustments specified in sections 2.2.2 and 2.2.3 are required. The calibration adjustments given in this section should be made only to correct power supply output voltages or substandard performance.

The instrument should be calibrated per the procedures in this section only if correct test equipment, operating within its calibration period, is available. The instrument should be given a one-hour warmup at typical operating temperature before any adjustment is made.

4.7.1 Adjustment of -12.3V Power Supply Output

With the DC Standard Differential Voltmeter measure the potential across filter capacitor C32. If the potential is not within the range 12.298 to 12.302 volts, adjust A35R9 for exactly 12.3 volts across C32. (See Figure 4.4 for locations.) Tap circuit board A35 to check stability of the adjustment; if necessary, reset A35R9 for 12.3 volt output.

4.7.2 Adjustment of -35V Power Supply Output

With the DC Standard Differential Voltmeter measure the potential across filter capacitor C10. If the potential is not within the range of 34.850 to 35.150 volts, adjust A7R10 for exactly 35 volts across C10. (See Figures 4.3 and 4.6 for locations.)

4.7.3 Calibration of Overload Detection

Calibrate Overload Detection whenever the OVERLOAD indicator is lighted by an overrange input that is less than 308% of full scale or greater than 315% of full scale. (See performance check 1, Table 4.3.) Proceed as follows:

1. On any range but the most sensitive, apply a negative dc input voltage that is 310-311% of full scale on the next lower range. (For example, apply -31.05 vdc to the DY-2401C set for 100V range.)

2. Select next lower range and check for OVERLOAD indication.

3. If OVERLOAD indicator does not light, slowly adjust A10R2 counterclockwise to make it light. See Figure 4.3 for location of adjustments.

4. If OVERLOAD indicator lights in step 2, set A10R2 clockwise until it no longer lights, then perform step 3.

5. Repeat steps 1-4 with positive input voltage, but set A16R86 for correct response instead of A10R2.

4.7.4 Calibration of Internal 1V Reference Standard

Whenever the internal reference reading obtained from performance check 4 of table 4.3 is outside the range of 99.93-1000.07 MILLIVOLTS, set A35R21 to obtain a reading within the range of 999.99-1000.01 MILLIVOLTS. Tap circuit board A35 to check mechanical stability of the setting; if necessary, reset A35R21 for correct output from the internal reference standard. (See Figure 4.4 for location of A35R21.)

4.7.5 Calibration of Internal Time Base

Whenever the horizontal drift of the internal reference squarewave, determined in performance check 3 of Table 4.3, exceeds 2 centimeters in 1 second, set capacitor C4 for minimum drift. (Improve brightness of oscilloscope display by synchronizing from 100 kc output of Frequency Standard. See Figure 4.3 for location of C4.)

4.7.6 Coarse Full-Scale Calibration Adjustments (Figure 4.5)

Perform these adjustments only after replacement of parts on printed circuit assembly A31, A32, or A33. Gain access to adjustments per Section 4.5 (leaving A28 shield in place) and proceed as follows:

1. Zero the instrument per section 2.2.2.

2. Set the RANGE switch to INT+1V and mechanically center the front panel CAL+ adjustment.

3. Set A33R4, the +FULL SCALE CAL ADJustment, for reading within the range of +999.80 to +1000.20 MILLIVOLTS. Tap plug-in assembly A33 to check mechanical stability of the setting; if necessary, reset A33R4 for correct reading.

4. Repeat steps 2 and 3 with the RANGE switch at INT-1V and the CAL- adjustment centered. Set A32R4 for reading within the range of -999.80 to -1000.20 MILLIVOLTS.

5. Complete normal full-scale calibration of the DY-2401C per section 2.2.3.

4.7.7 + and - Trigger Level Adjustments

Perform either or both of these adjustments after replacement of parts on printed circuit assembly A32 or A33. With top and bottom of the instrument both accessible as shown in Figures 4.3 and 4.5, proceed as follows:

1. Set the RANGE switch to INT+1V.

2. With oscilloscope, monitor waveform at A31(15); ground oscilloscope probe at A31(P29). See Figure 4.3 for locations of A31(15) and (P29).

3. Set A33R27 for a maximum negative peak amplitude of -0.1v.

NOTE
See Figure 4.5 for locations of A33R27 and A32R27.

4. Set the RANGE switch to INT -1V

5. Set A32R27 for a maximum positive peak of +0.1v.

4.7.8 Input Attenuator Calibration (Using Known Input Voltage)

Calibration of the input attenuator by this method requires the equipment and setup used for performance check 5 in Table 4.3. Gain access to adjustments as specified in Section 4.5, but do not remove the A28 cover shield. Proceed as follows (see Figures 4.1 (A) and (B), and 4.5):

1. Zero the DY-2401C using the procedure in section 2.2.2.

2. Connect the DC Standard, DC Null Voltmeter, 1 Volt Calibration Standard, Precision Volt Box, and DY-2401C as shown in Figures 4.1(A) and (B) for 0.1V check.

NOTE

Operate the DC Null Voltmeter from its internal batteries; do not connect it to the ac line.

3. Set the DC Standard output voltage to produce a null on the most sensitive range of the DC Null Voltmeter.

4. On the DY-2401C, set the RANGE switch to .1V and the CAL+ adjustment for +99.108 MILLIVOLTS reading.

NOTE

The 100K input impedance of the DY-2401C on the .1V RANGE loads the output of the Precision Volt Box so that the input voltage is +99.108 millivolts.

5. Change DY-2401C connection to that shown in Figure 4.1(A) for 1V check.

6. Set DY-2401C RANGE switch to 1V and set the 1V calibration adjustment (marked on A28 cover) for +1000.00 MILLIVOLTS reading.

7. Change connections to those shown in Figure 4..1(B) for 10V check and set DC Standard to produce a null on the most sensitive range of the DC Null Voltmeter.

8. Set RANGE switch to 10V and set the 10V calibration adjustment for +10.0000 VOLTS reading.

9. Change connections to those shown in Figure 4.1(B) for 100V check and set DC Standard to produce a null on the most sensitive range of the DC Null Voltmeter.

10. Set RANGE switch to 100V and set the 100V calibration adjustment for +100.000 VOLTS reading.

11. Change connections to those shown in Figure 4.1(B) for 1000V check and set DC Standard to produce a null on the most sensitive range of the DC Null Voltmeter.

12. Set RANGE switch to 1000V and set the 1000V calibration adjustment for +1000.00 VOLTS reading.

4.7.9 Overrange Linearity Adjustment (See Figure 4.5)

The negative and positive overrange linearity adjustments of the DY-2401C are A32R32 and A33R32. These adjustments are set at the factory to provide overrange accuracy better than that specified for the instrument and should not be reset unless improved overranging linearity is absolutely necessary. An adjustable dc standard capable of supplying a suitable range of positive or negative voltages that are known accurately to ±0.002% or better is required. If such a standard is available, overranging linearity can be optimized by the following general procedure:

1. After one hour warmup zero the DY-2401C per Section 2.2.2. Perform the full-scale adjustments in Section 2.2.3, but use the 1V RANGE and + and -1.00000 volt inputs from the dc standard.

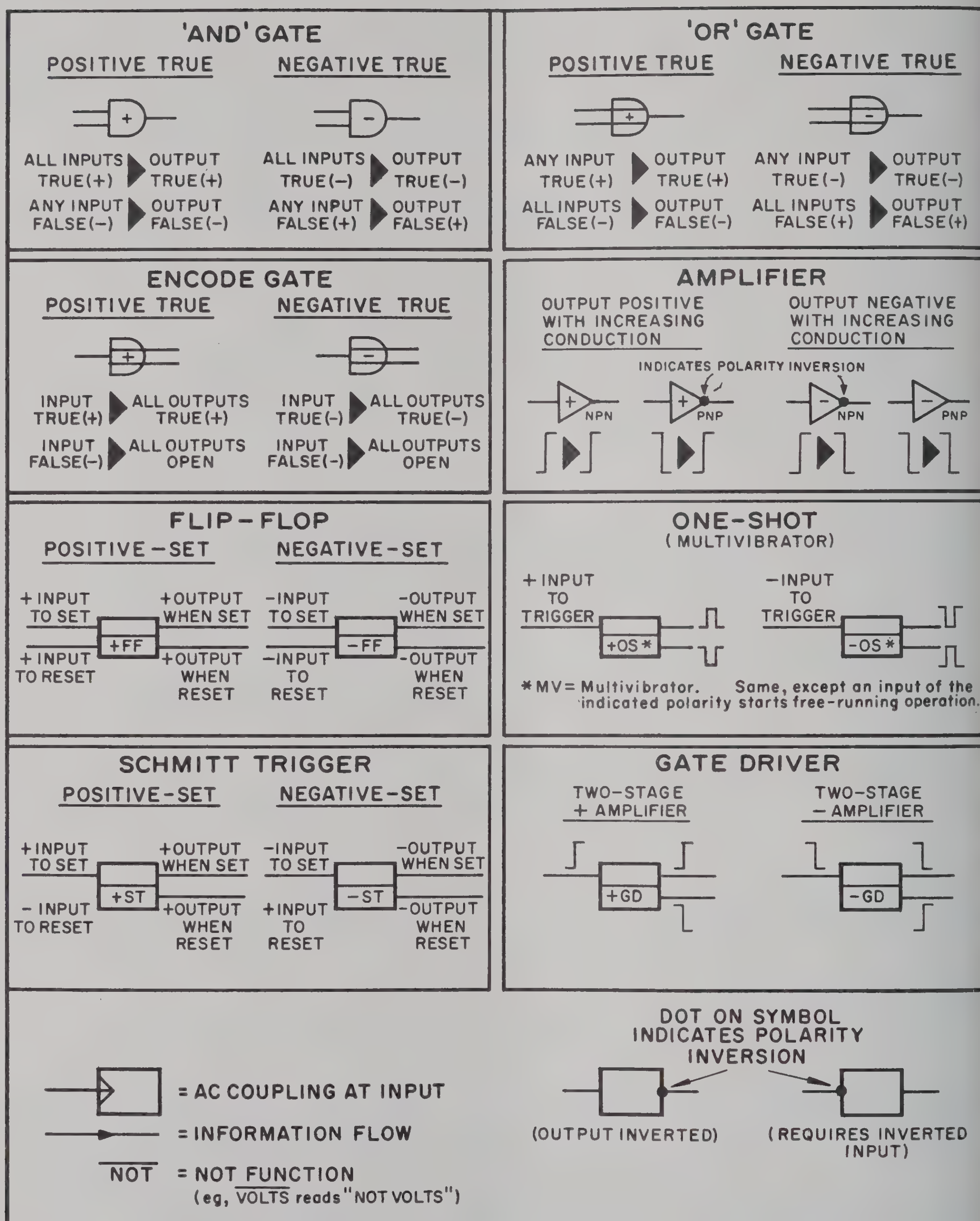
2. Before touching A32R32 or A33R32, make a complete plot from full scale to three times full scale, at 0.1 full scale or shorter intervals, of the high or low deviation of DY-2401C readings from the known voltages supplied by the dc standard. Plot both positive and negative inputs.

3. If the linearity characteristic plotted in step 2 is unacceptable, adjust A32R32 or A33R32 to correct it. When capacitor C6 (Figure 4.43) is next to R32, clockwise adjustment of R32 compensates for low readings. If an inductor is in the C6 position, clockwise adjustment of R32 compensates for high readings.

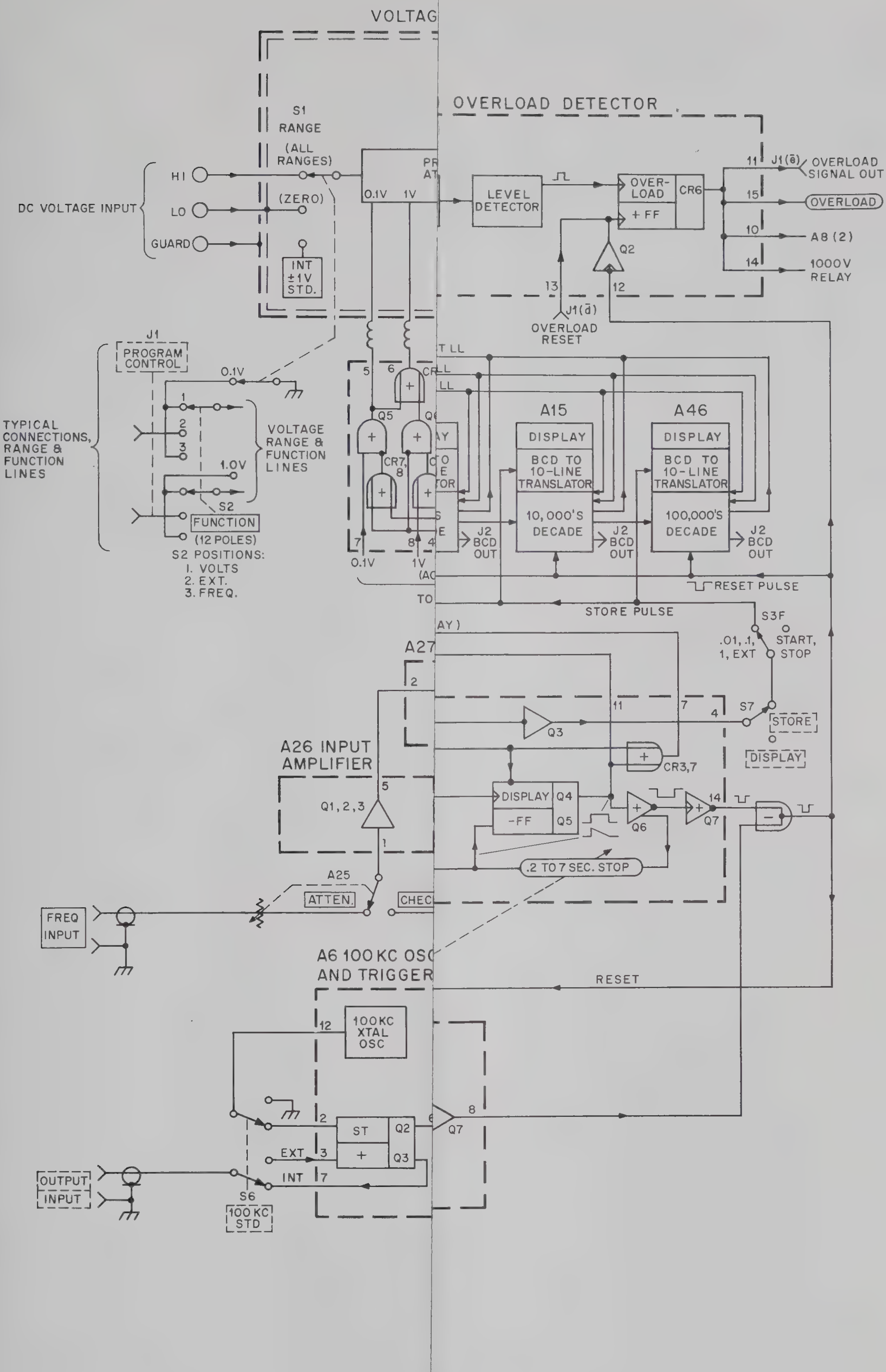
4. Repeat steps 2 and 3 until acceptable linearity is achieved. Then reset coarse full scale calibration adjustments as specified in Section 4.7.6.

4.7.10 Photochopper Drive Oscillator Adjustment

The DRIVE OSC. ADJustment shown in Figure 4.5 sets the frequency of the photochopper drive oscillator. This frequency should be 240 ±5 cps when line voltage to the DY-2401C is at design center (115 or 230 vac). The frequency may be counted through a high impedance probe at either terminal of A31C27 if the drive oscillator cover is removed.

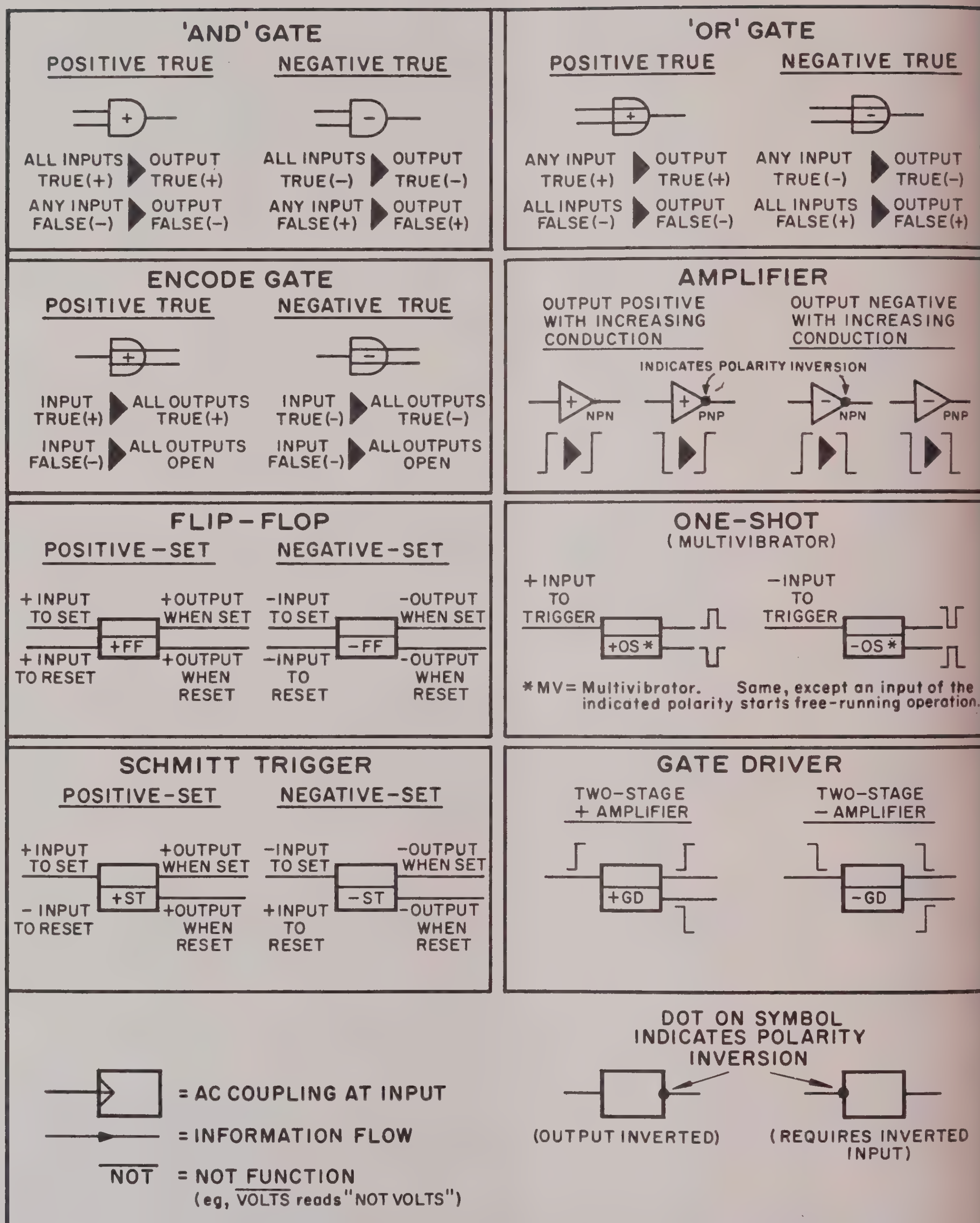


EXPLANATION OF BASIC LOGIC SYMBOLS
FIGURE 4.9

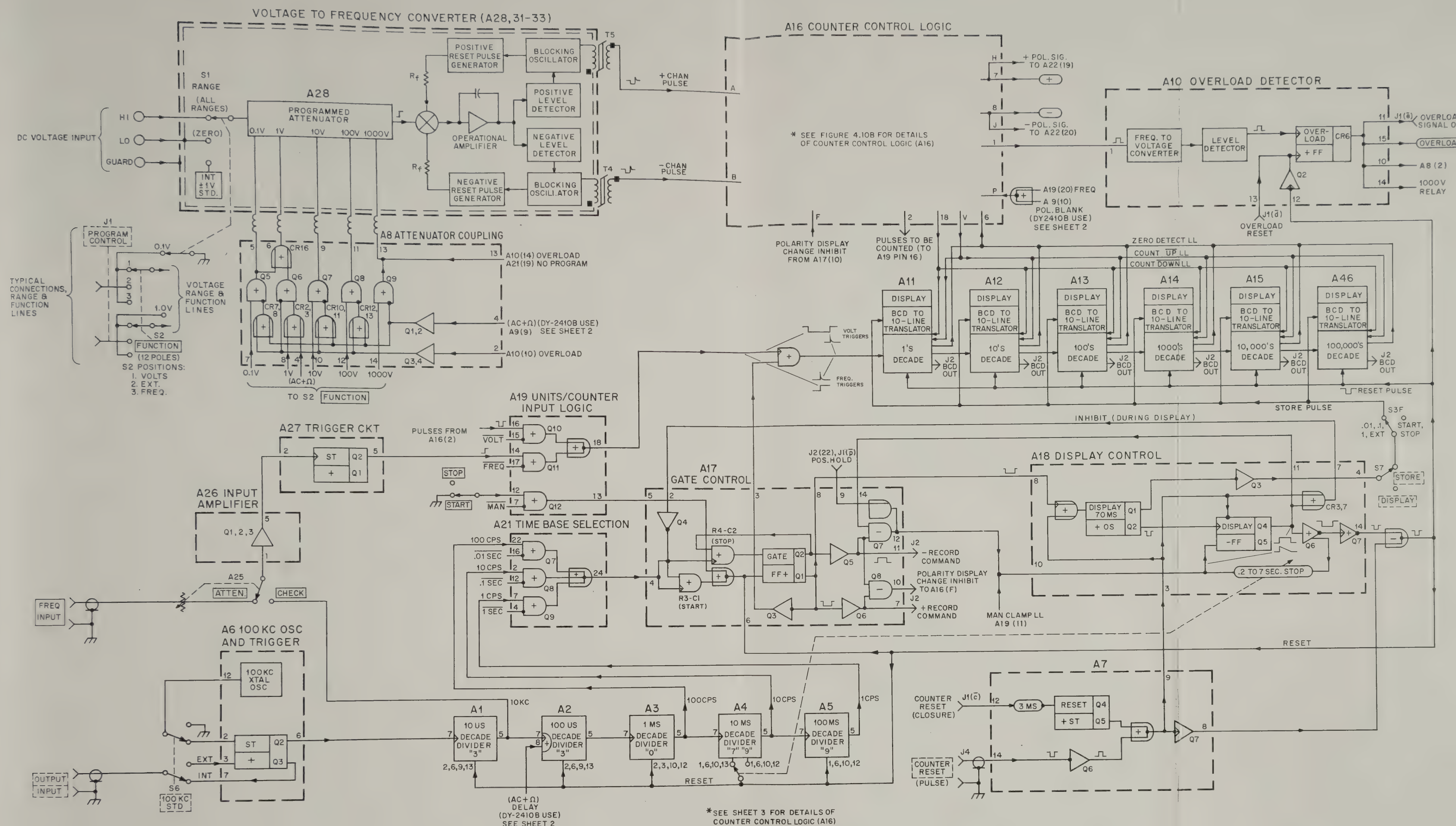


OVERALL LOGIC DIAGRAM
(V-F Converter and Counter)

FIGURE 4.10A



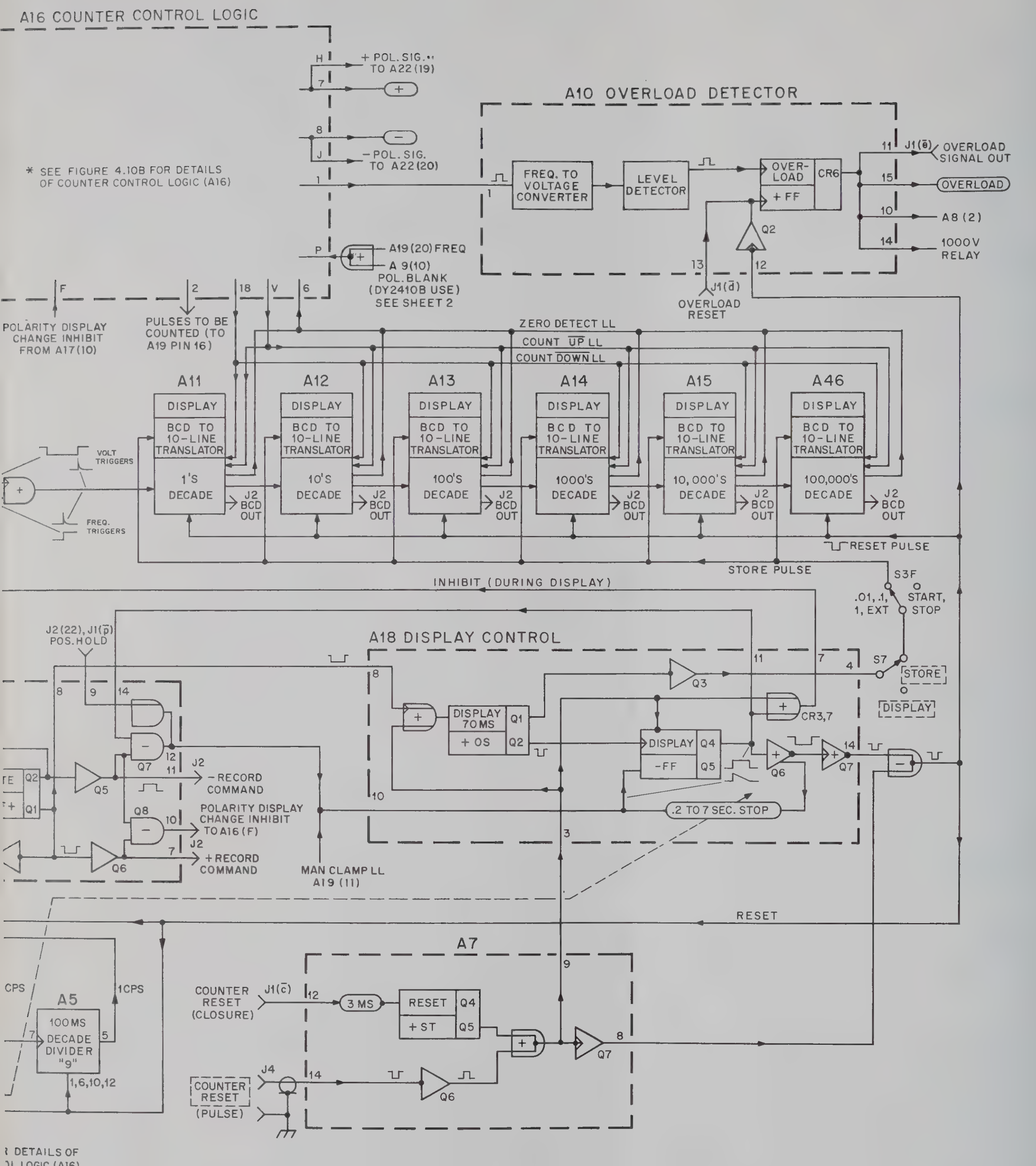
EXPLANATION OF BASIC LOGIC SYMBOLS
FIGURE 4.9



05950-1521-1

OVERALL LOGIC DIAGRAM
(V-F Converter and Counter)

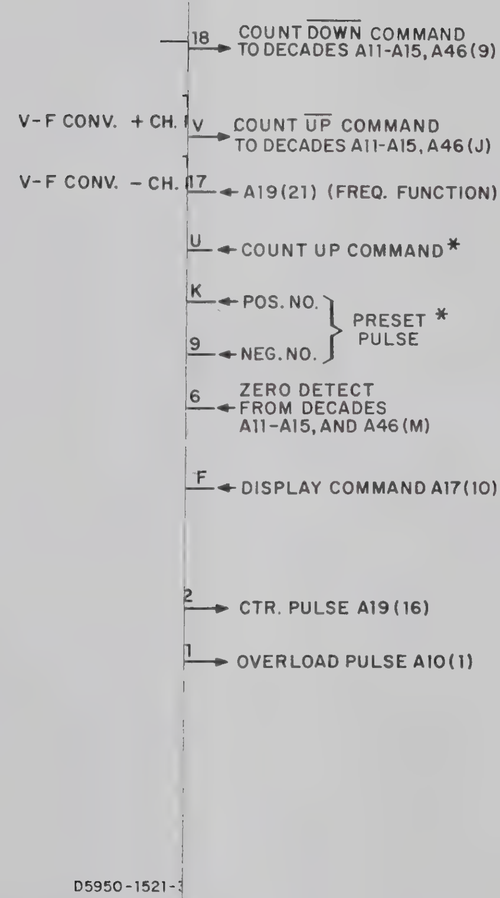
FIGURE 4.10A



OVERALL LOGIC DIAGRAM

(V-F Converter and Counter)

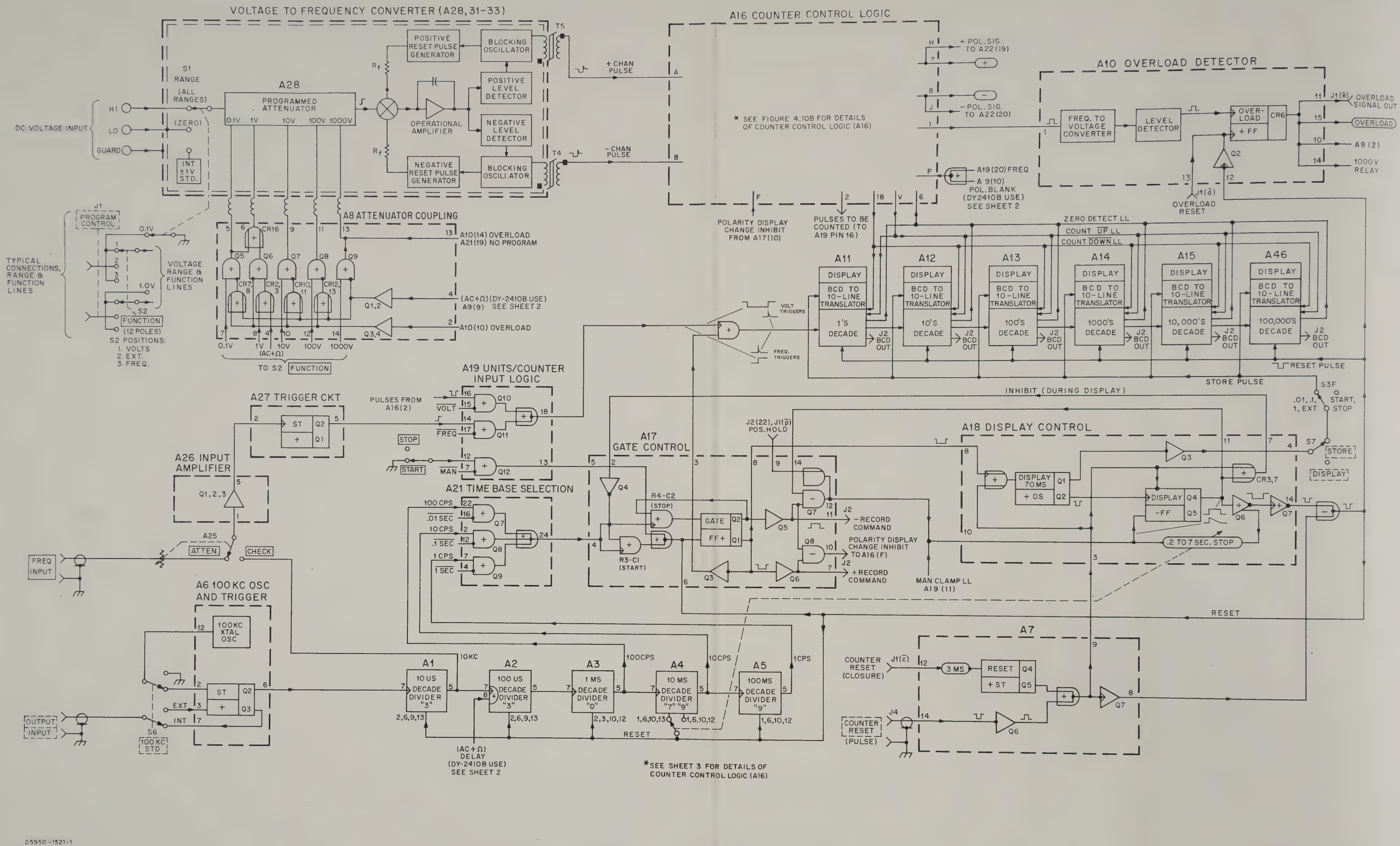
FIGURE 4.10A



OVERALL LOGIC DIAGRAM

(Counter Control Logic)

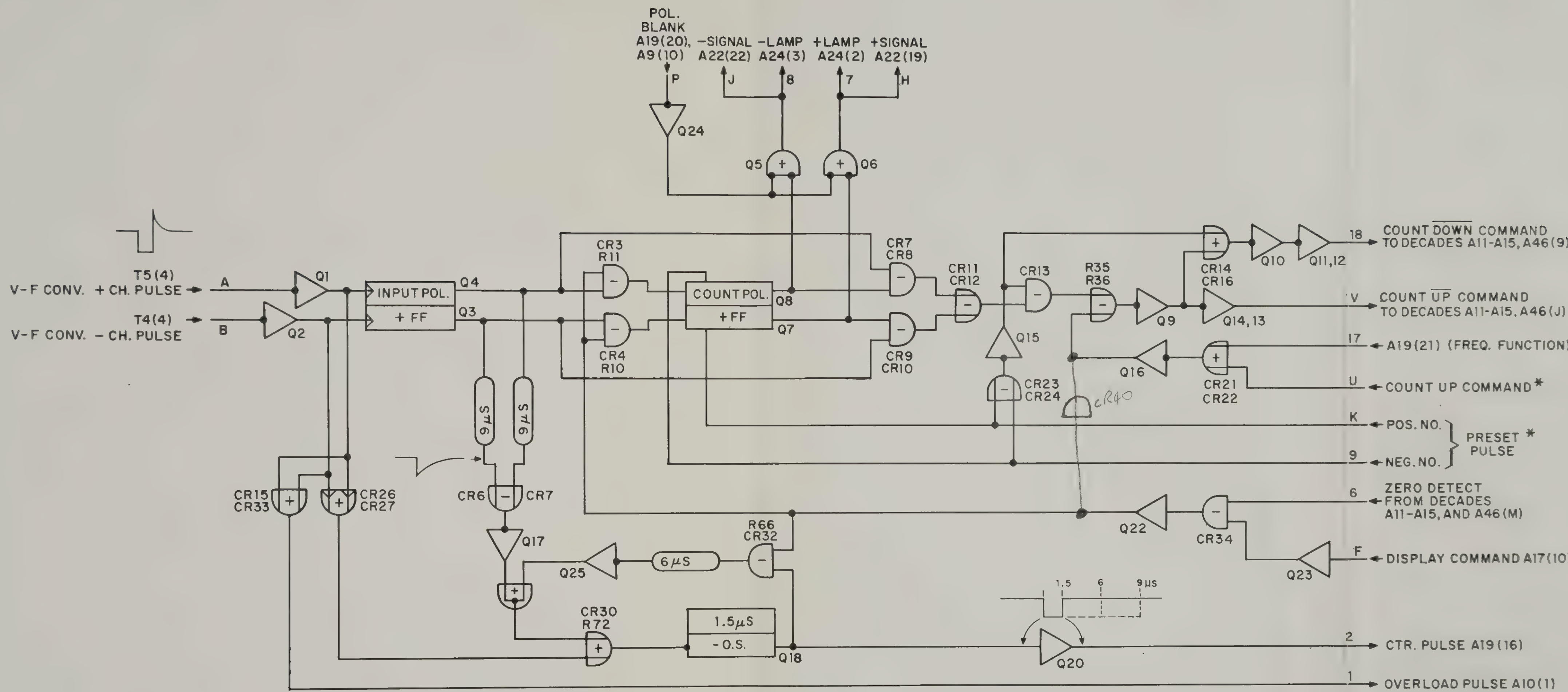
FIGURE 4.10B



OVERALL LOGIC DIAGRAM

(V-F Converter and Counter)

FIGURE 4.10A



NOTES:

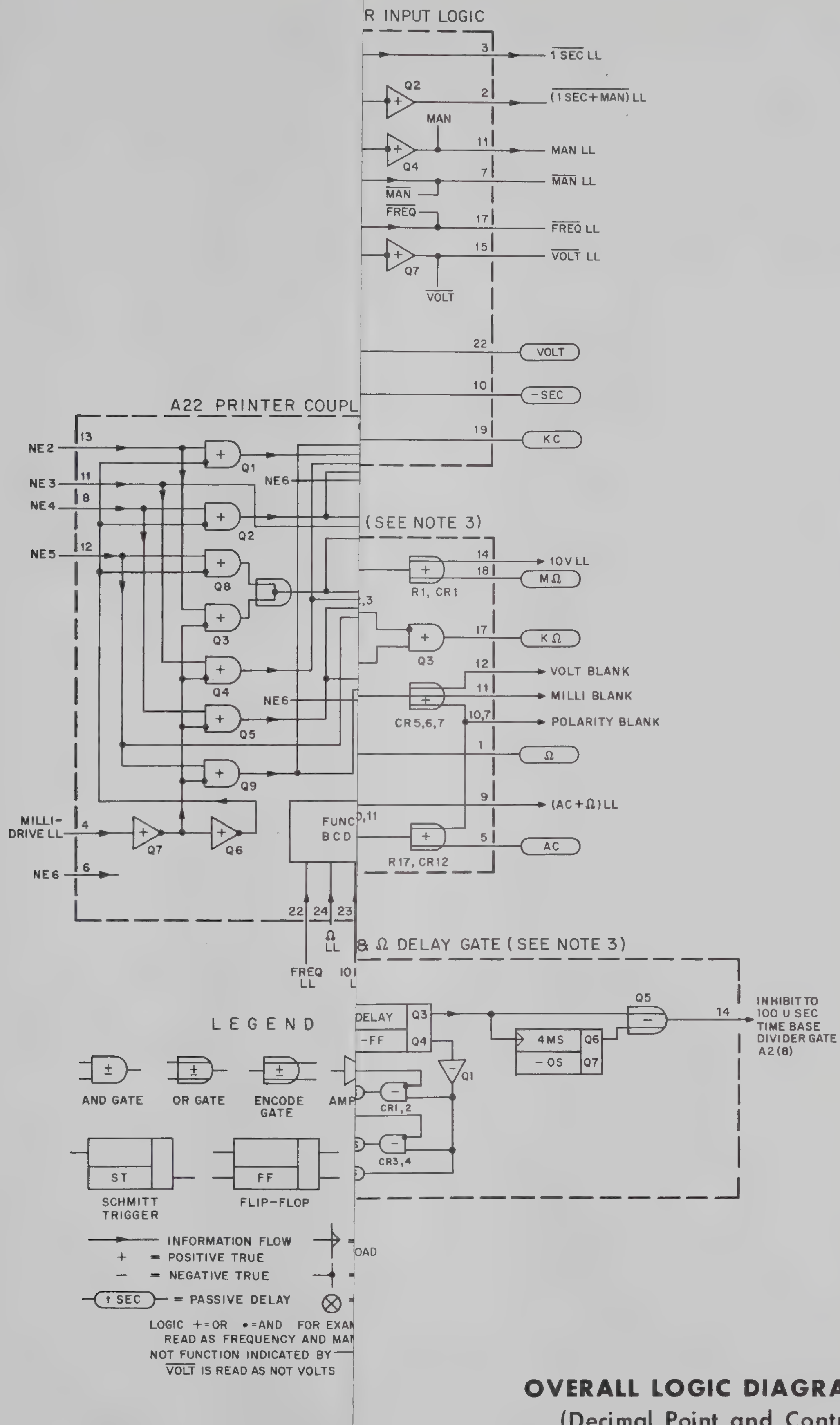
1. POSITIVE TRUE LOGIC USED
2. * THESE INPUTS ARE NOT CONNECTED ON THE STANDARD INSTRUMENT

D5950-1521-3

OVERALL LOGIC DIAGRAM

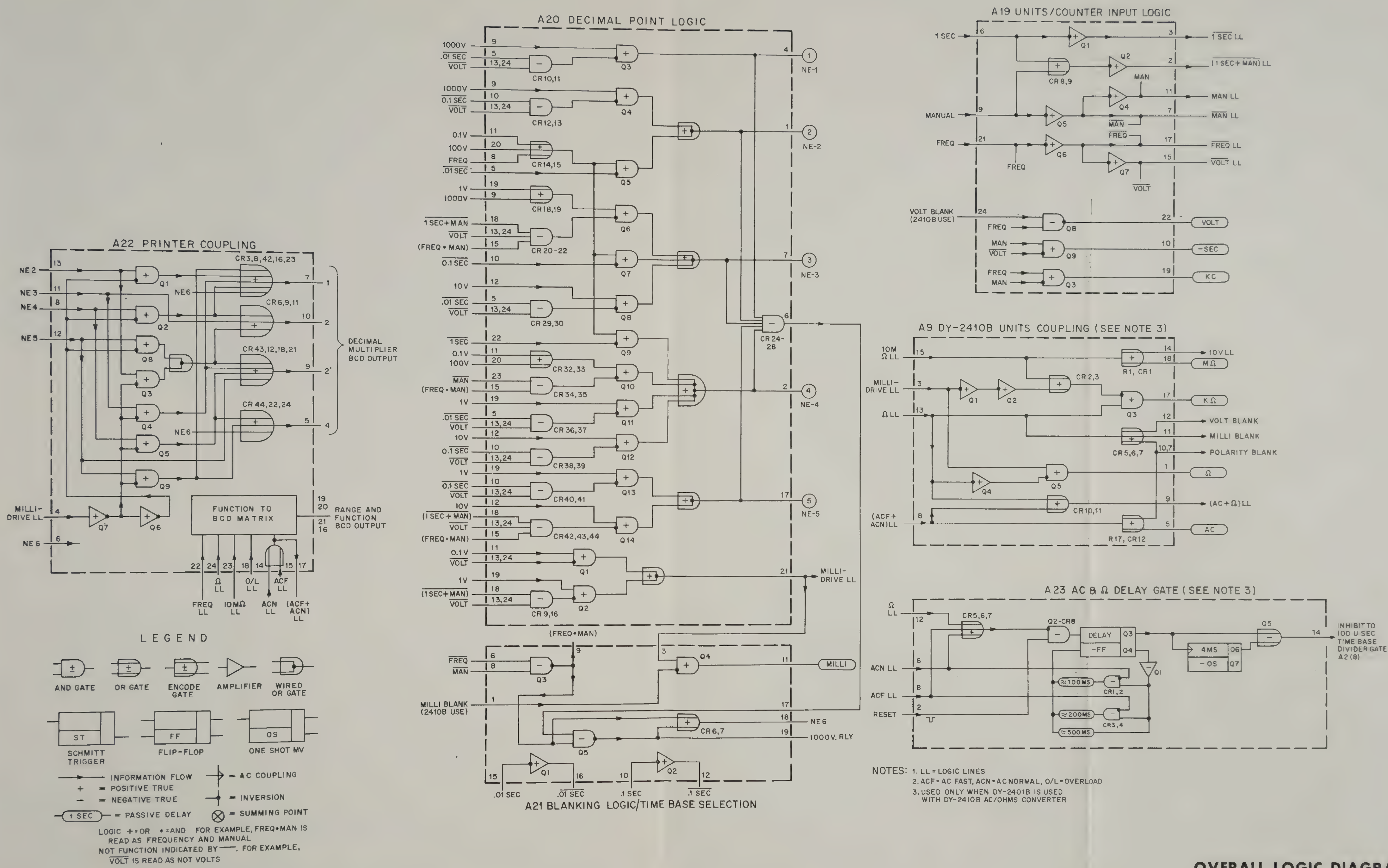
(Counter Control Logic)

FIGURE 4.10B



OVERALL LOGIC DIAGRAM
(Decimal Point and Control)

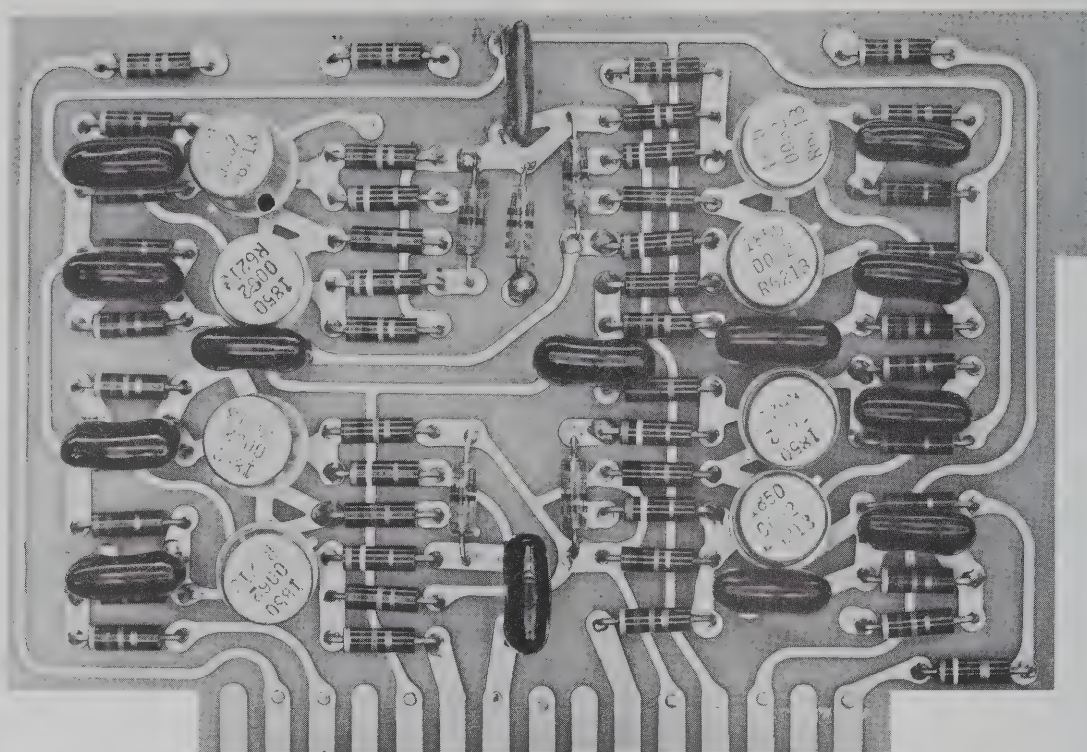
FIGURE 4.10C

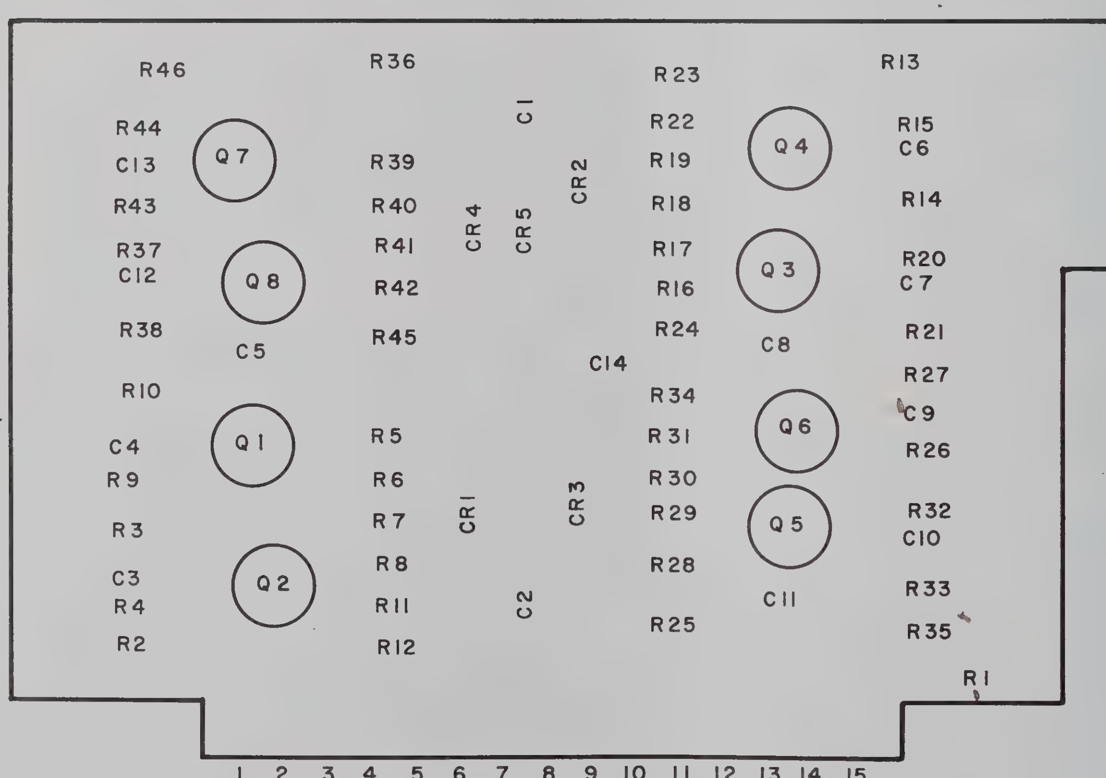


D5950-1521-2

OVERALL LOGIC DIAGRAM
(Decimal Point and Control)

FIGURE 4.10C

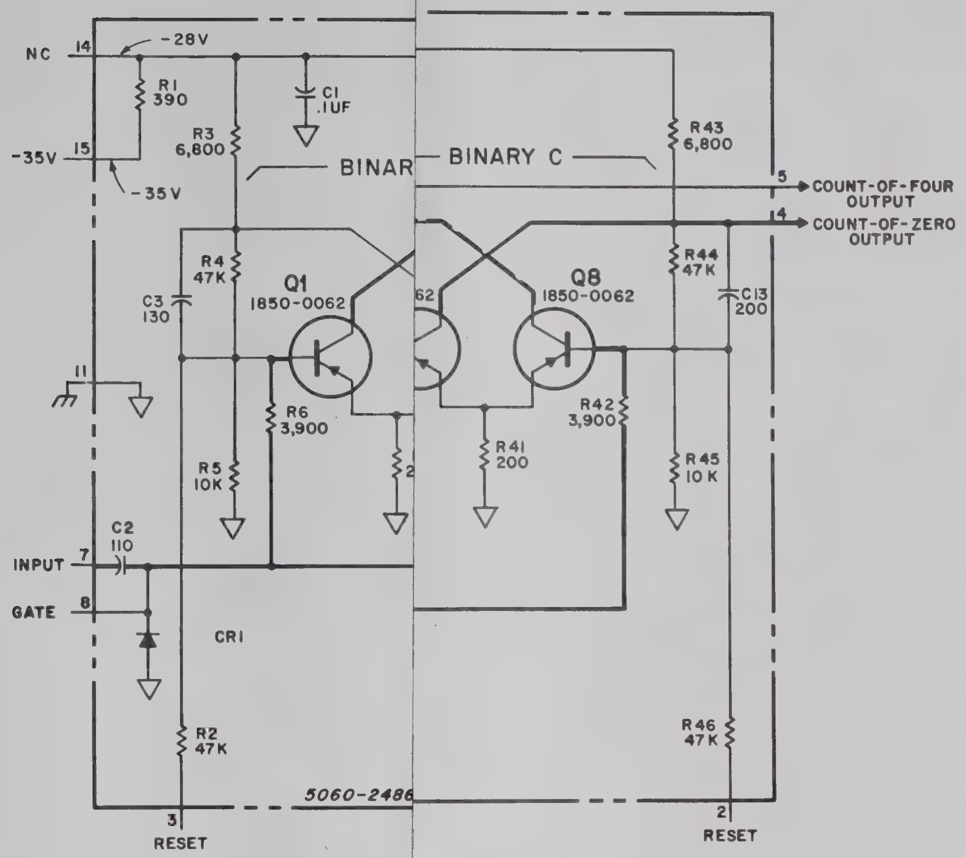




DECADE DIVIDER ASSEMBLY (A1-A5)

5212A-65C (5060-2486)

FIGURE 4.11



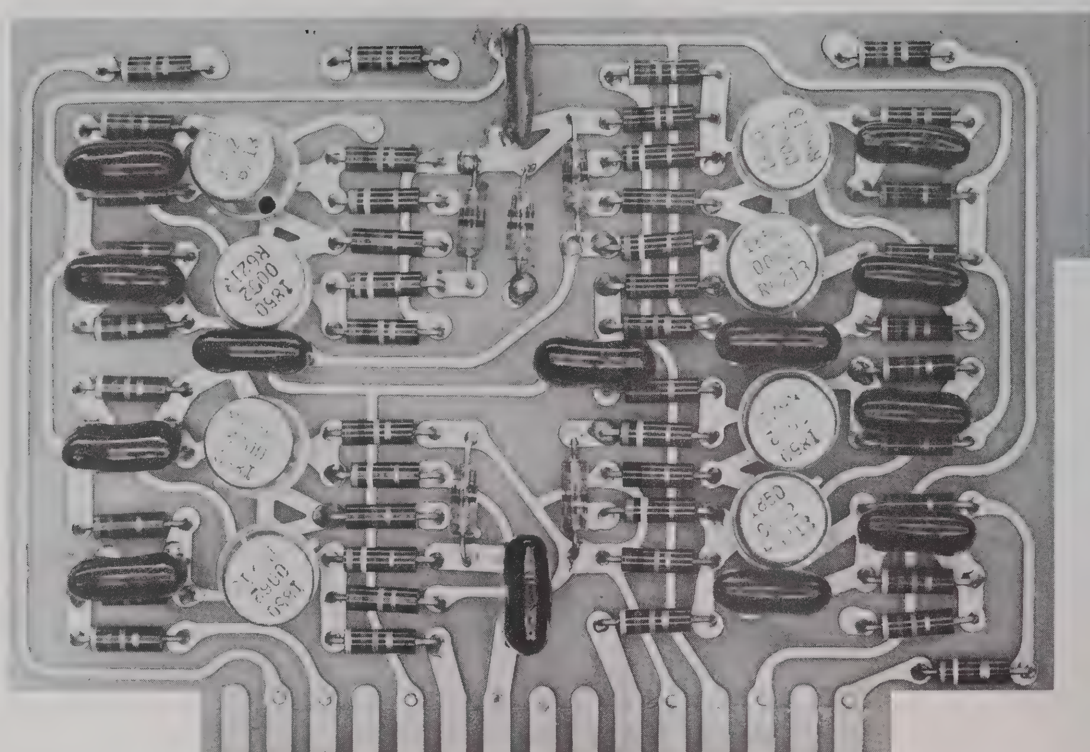
NOTES

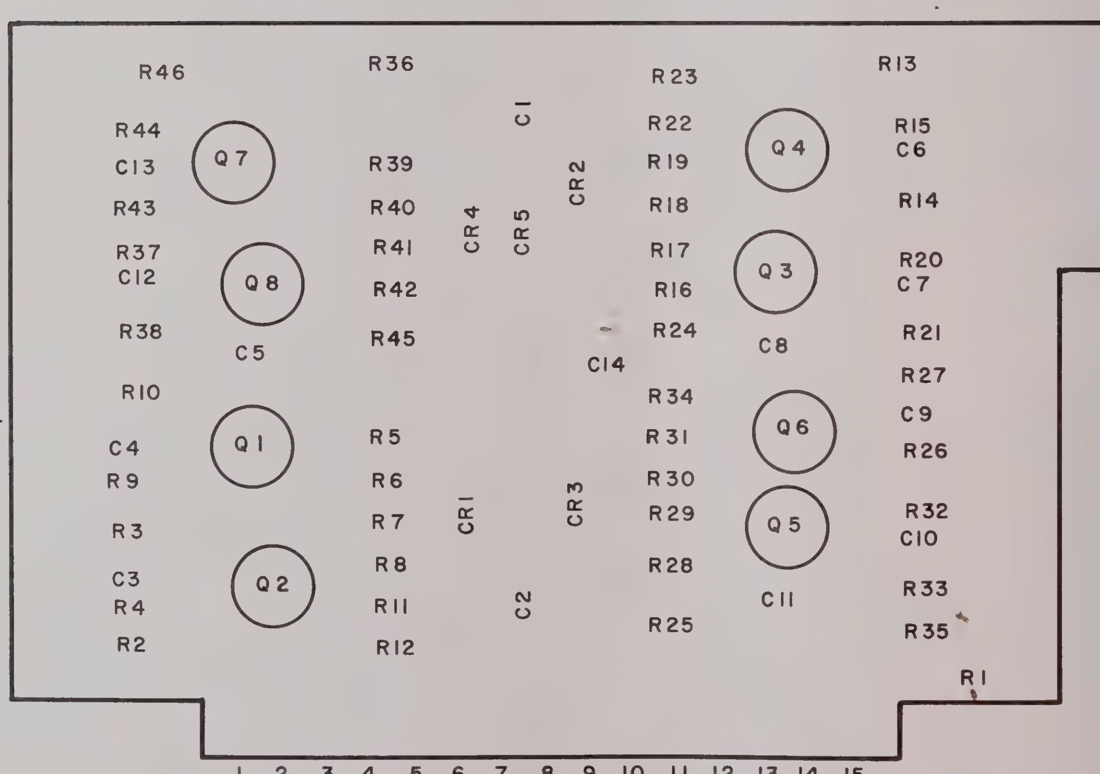
1. TYPICAL CIRCUITRY EXTERNAL TO DECADE D
IS SHOWN; FOR EXACT CONNECTION AND RE
DESIGNATIONS OF EXTERNAL COMPONENTS,
OVERALL LOGIC DIAGRAM.
2. UNLESS OTHERWISE INDICATED:
RESISTANCE IN OHMS;
CAPACITANCE IN PICOFARADS
3. ⏚ = CHASSIS GROUND
▽ = CIRCUIT COMMON

D5060-2486

DECADE DIVIDER CIRCUIT (A1 - A5)

FIGURE 4.12

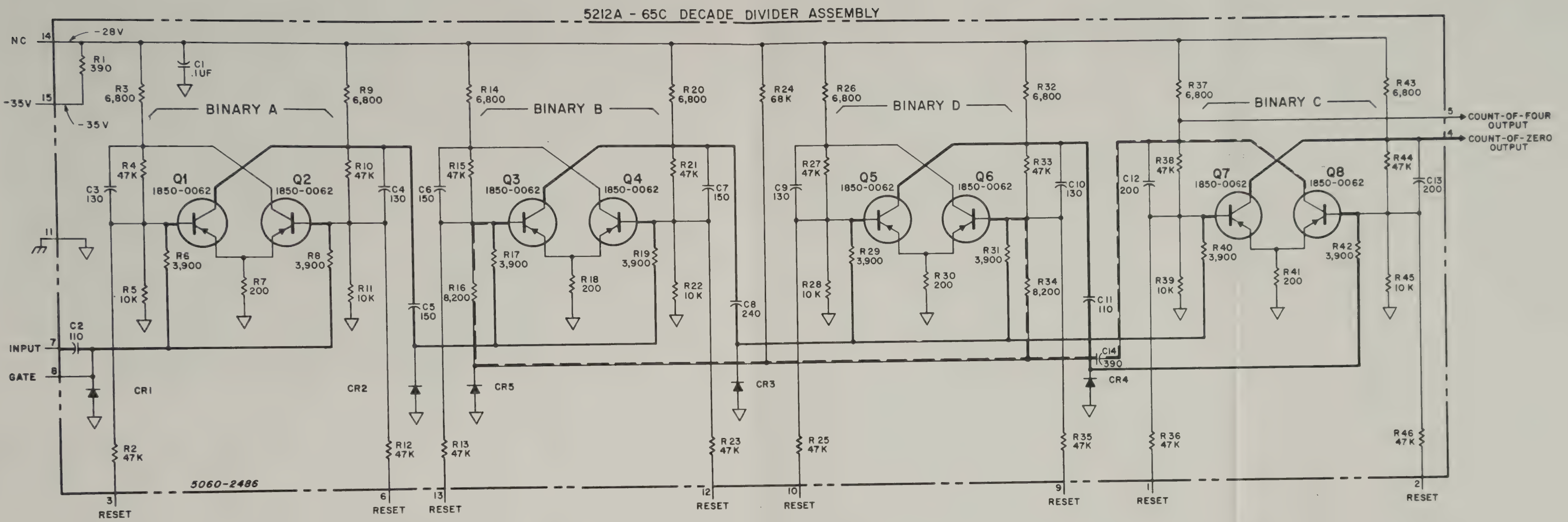




DECADE DIVIDER ASSEMBLY (A1-A5)

5212A-65C (5060-2486)

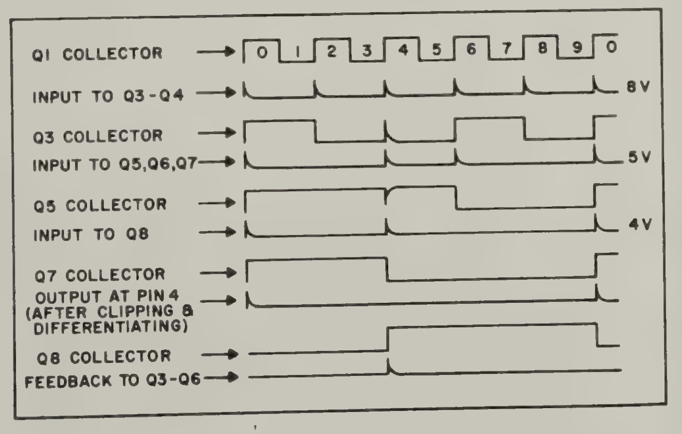
FIGURE 4.11



NOTES

1. TYPICAL CIRCUITRY EXTERNAL TO DECADE DIVIDER ASSY IS SHOWN; FOR EXACT CONNECTION AND REFERENCE DESIGNATIONS OF EXTERNAL COMPONENTS, REFER TO OVERALL LOGIC DIAGRAM.
2. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS; CAPACITANCE IN PICOFARADS
3. = CHASSIS GROUND
   = CIRCUIT COMMON

WAVEFORMS



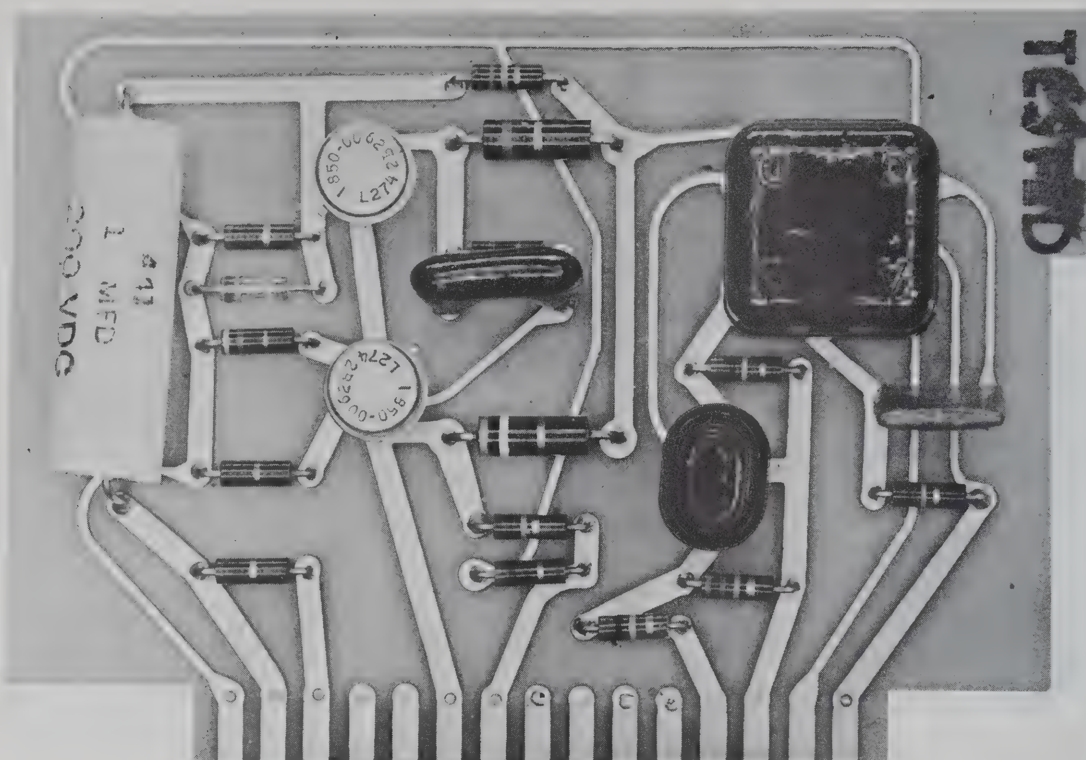
RESET WIRING

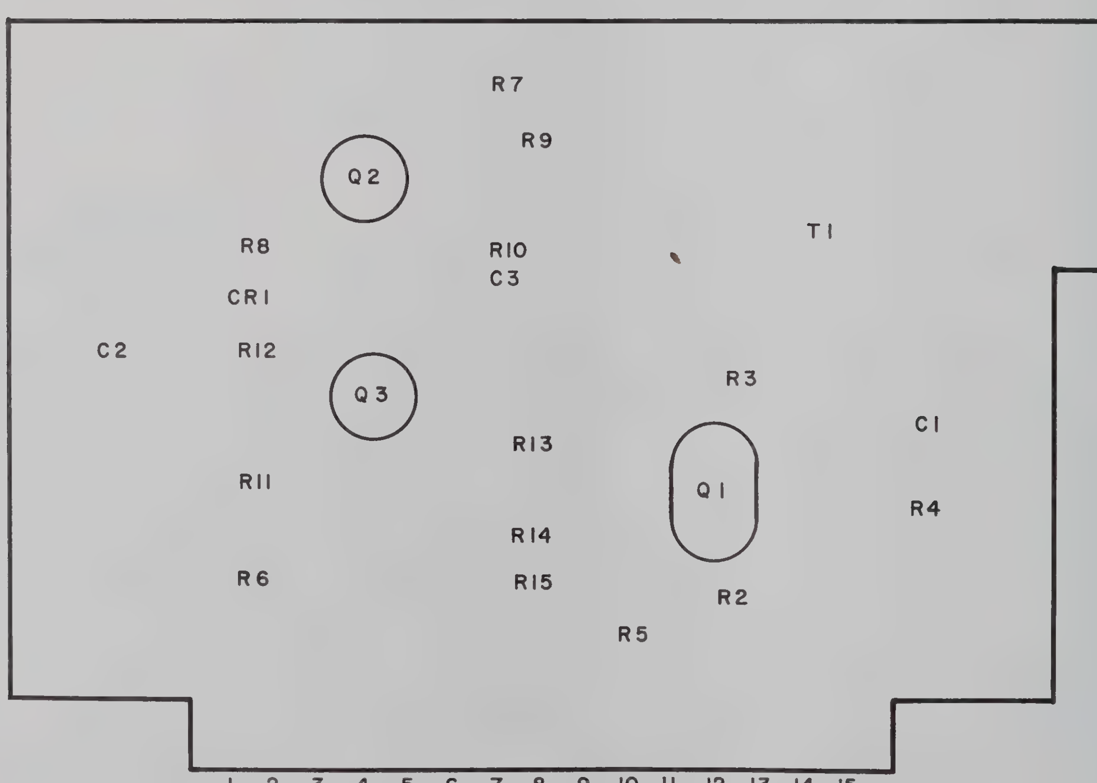
RESET NUMERAL	RESET PULSE (NEGATIVE) PIN CONNECTIONS			
0	3	13	10	1
1	6	13	10	1
2	3	12	10	1
3	6	12	10	1
4	3	12	10	2
5	6	12	10	2
6	3	13	9	2
7	6	13	9	2
8	3	12	9	2
9	6	12	9	2

D5060-2486

DECADE DIVIDER CIRCUIT (A1 - A5)

FIGURE 4.12

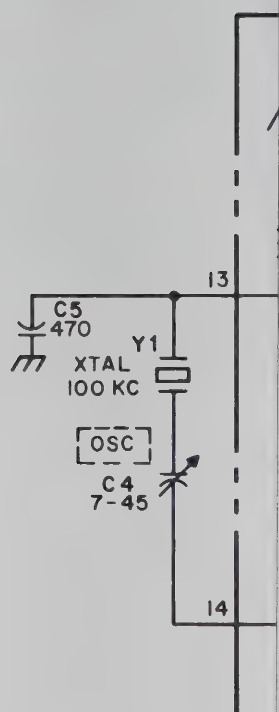




100 KC OSCILLATOR AND SCHMITT TRIGGER ASSEMBLY (A6)

5212A-65F (5060-2488)

FIGURE 4.13



NOTES

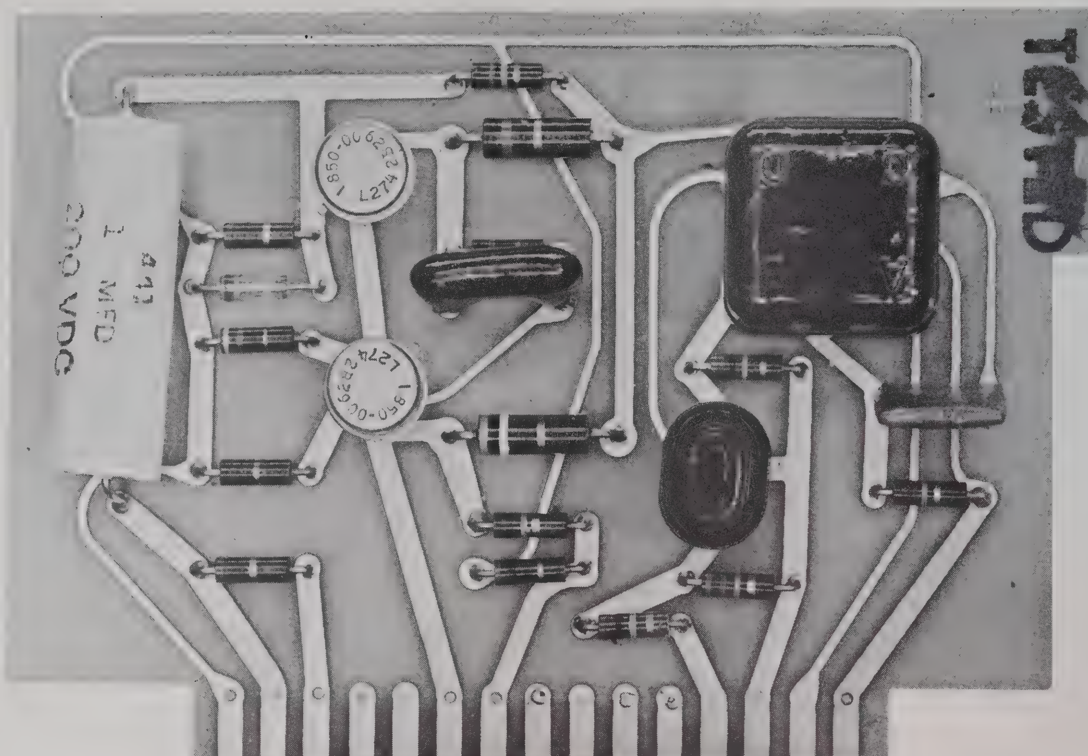
:HASSIS GROUND

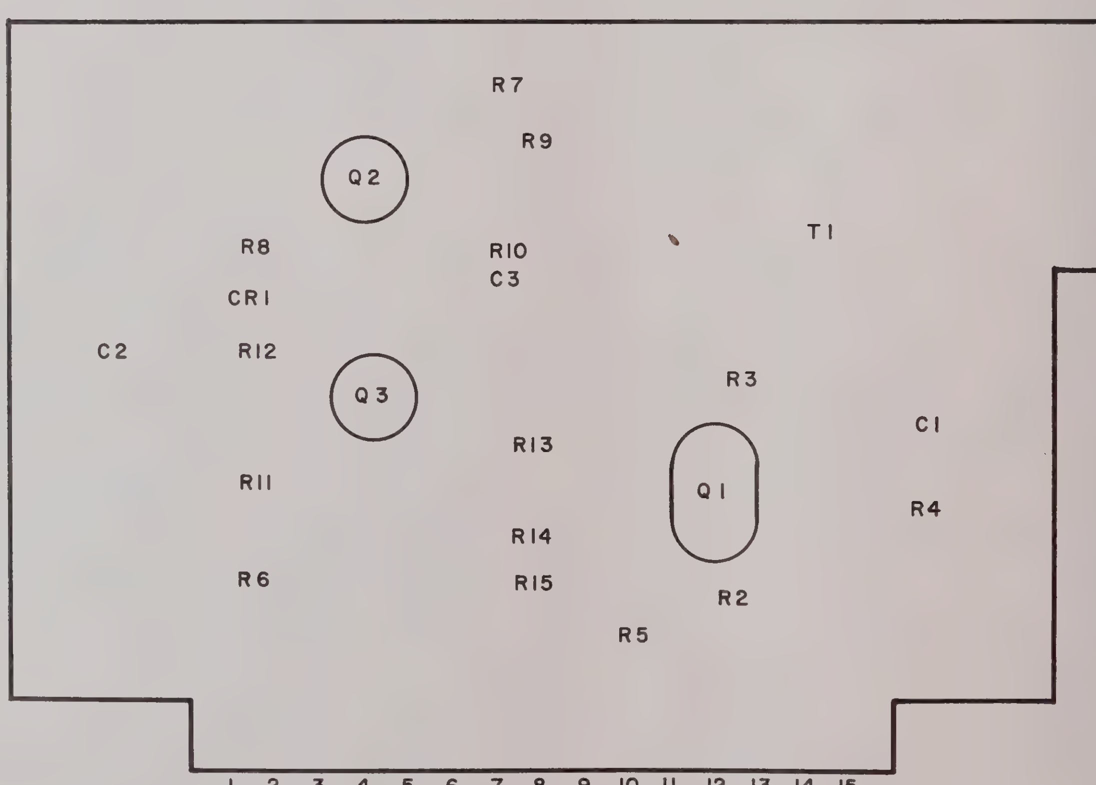
ESS OTHERWISE INDICATED:
RESISTANCE IN OHMS;
CAPACITANCE IN PICOFARADS

D5060-2488

100KC OSCILLATOR AND SCHMITT TRIGGER CIRCUIT (A6)

FIGURE 4.14

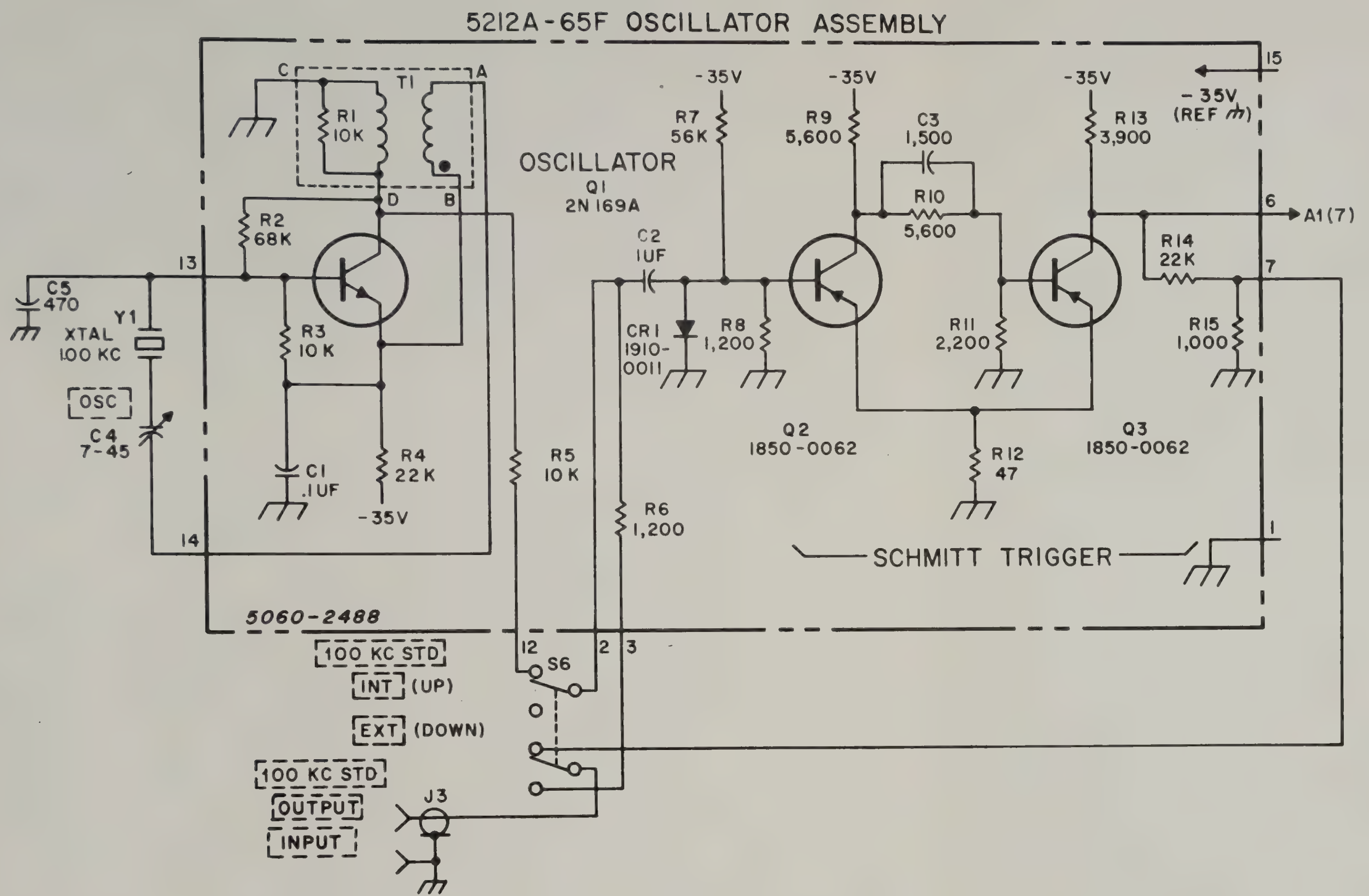




100 KC OSCILLATOR AND SCHMITT TRIGGER ASSEMBLY (A6)

5212A-65F (5060-2488)

FIGURE 4.13



NOTES

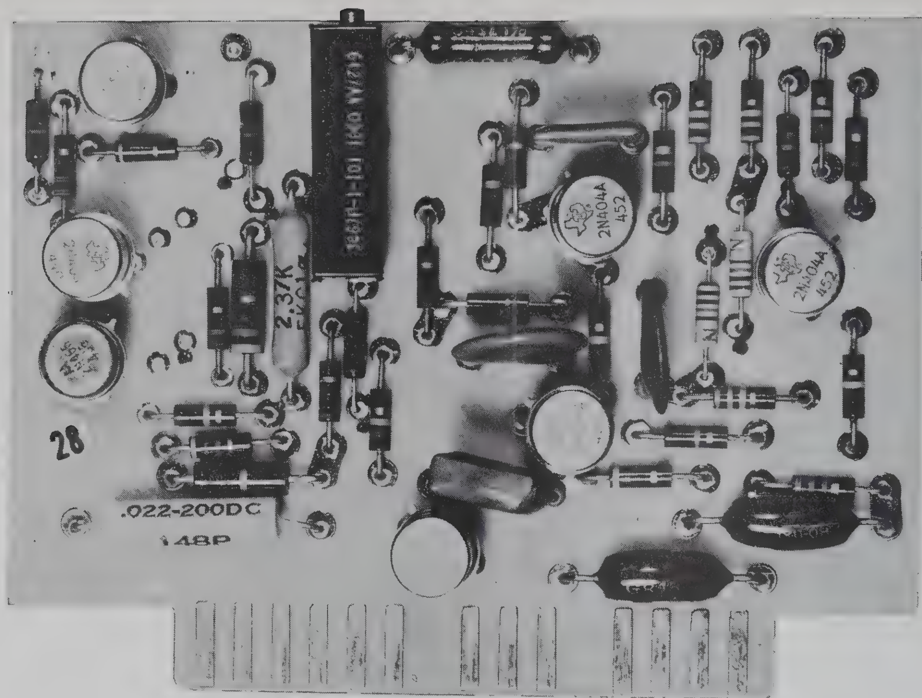
1. = CHASSIS GROUND

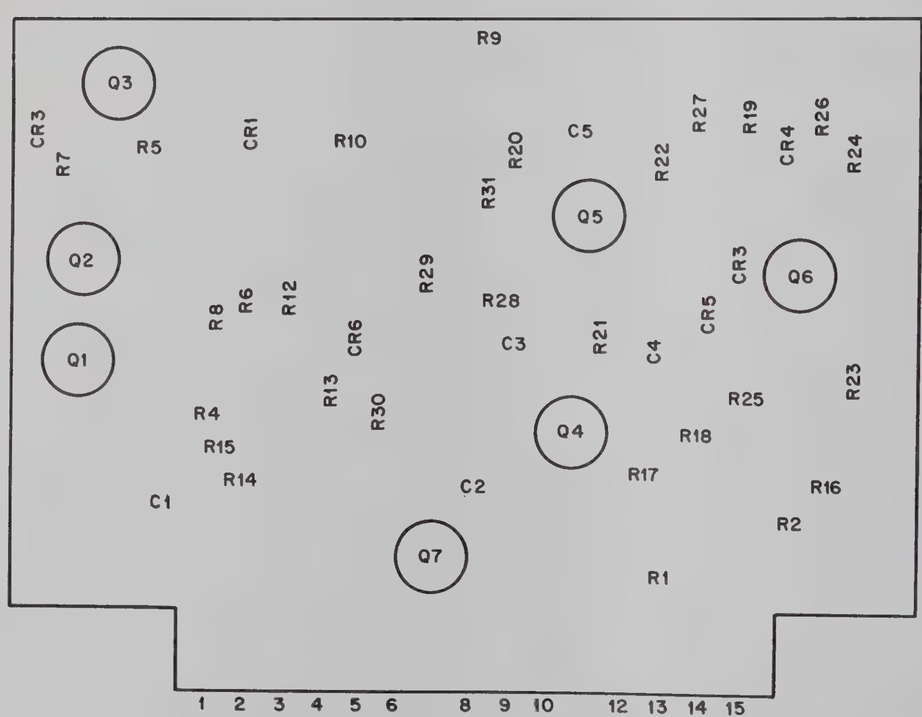
2. UNLESS OTHERWISE INDICATED:
RESISTANCE IN OHMS;
CAPACITANCE IN PICOFARADS

D5060-2488

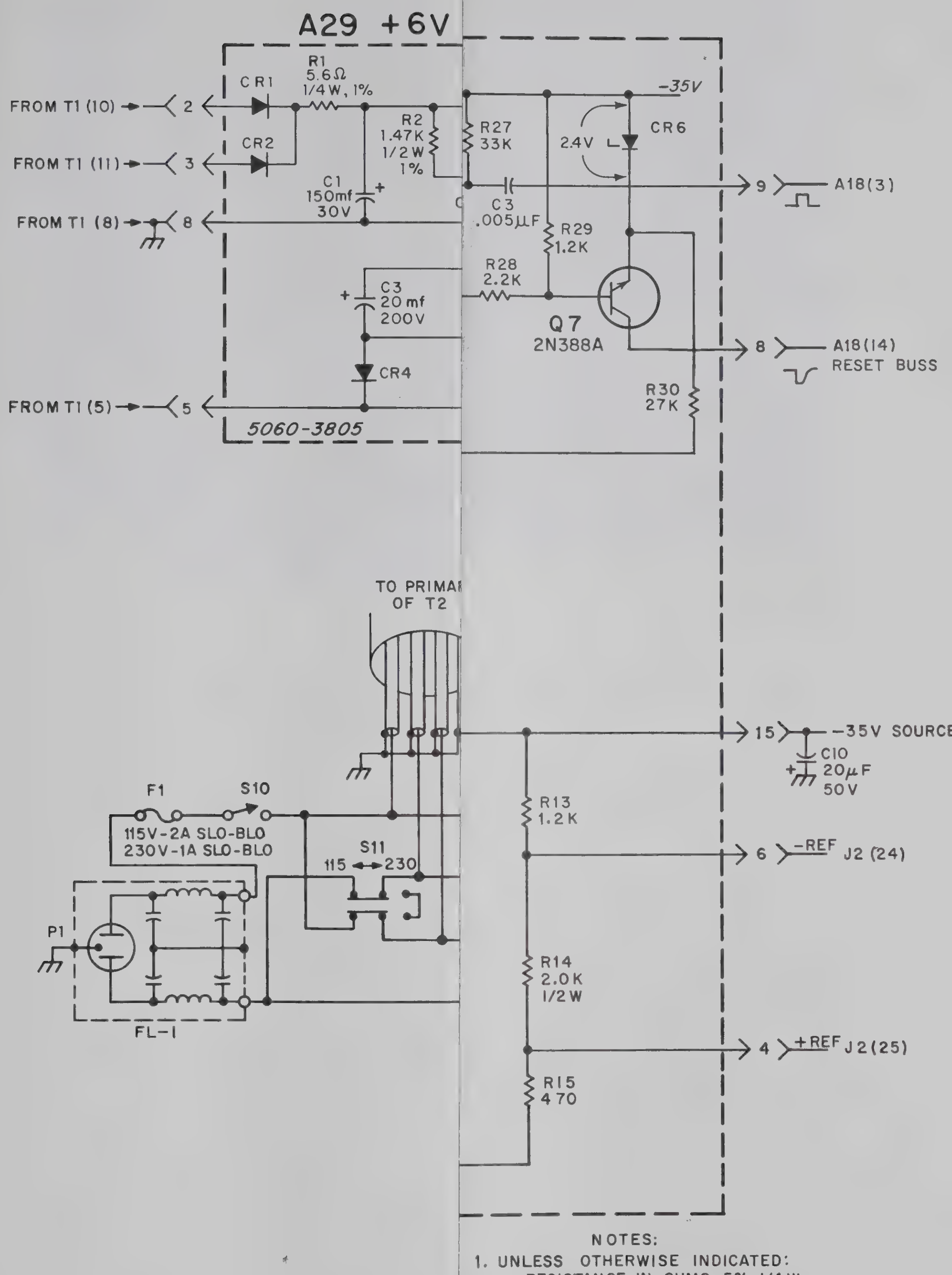
100KC OSCILLATOR AND SCHMITT TRIGGER CIRCUIT (A6)

FIGURE 4.14





-35V REGULATOR AND RESET ASSEMBLY (A7)
5060-3830

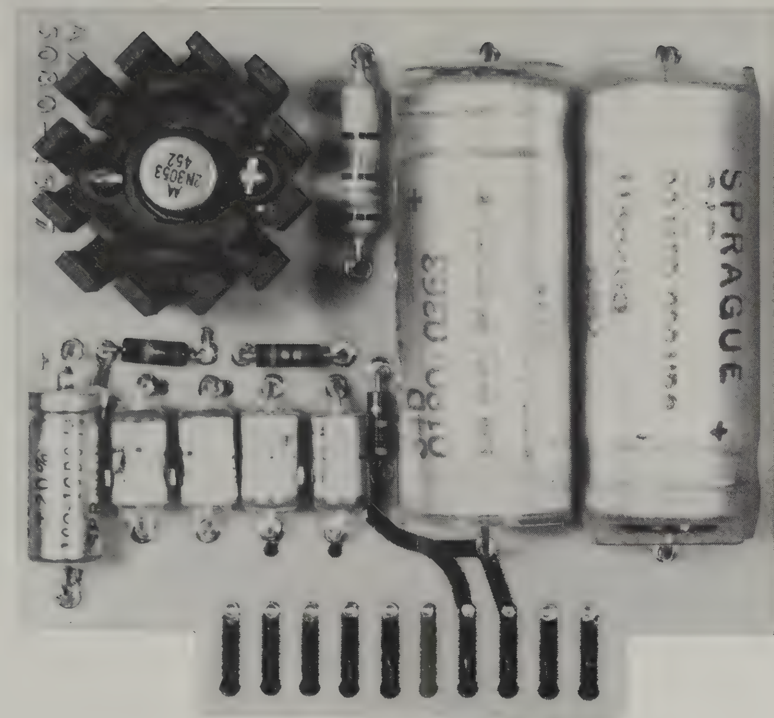


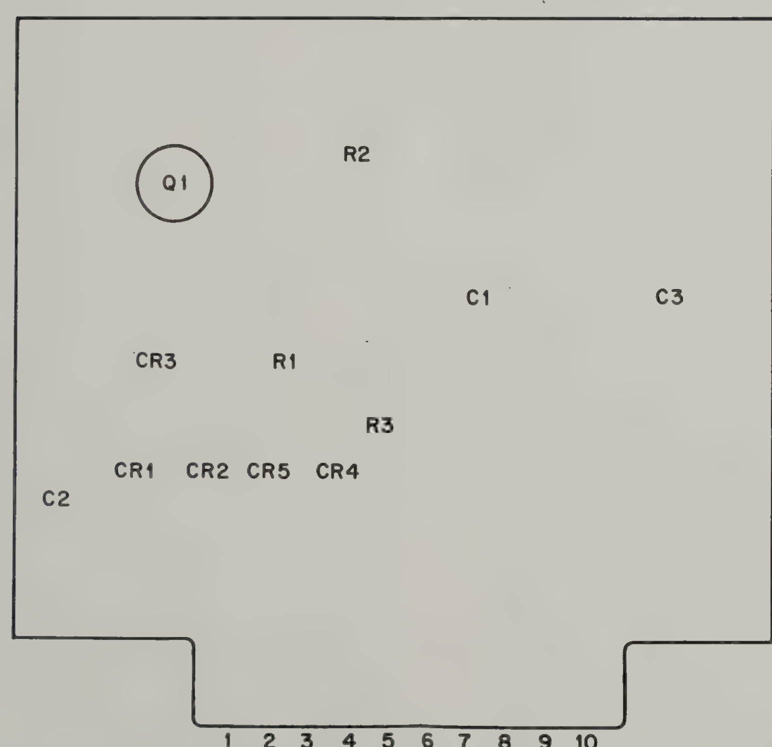
NOTES:

1. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS, 5%, 1/4 W
   CAPACITANCE IN PICOFARADS
2. ⏚ = CHASSIS GROUND

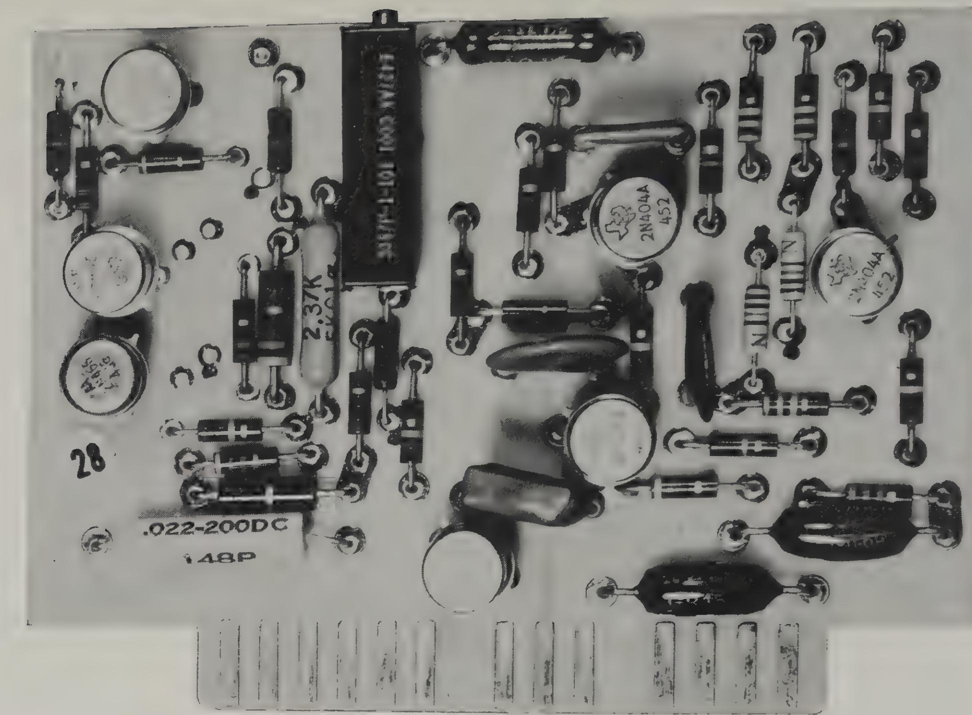
-35V REGULATOR AND RESET CIRCUIT (A7) AND +6V BIAS CIRCUIT (A29)

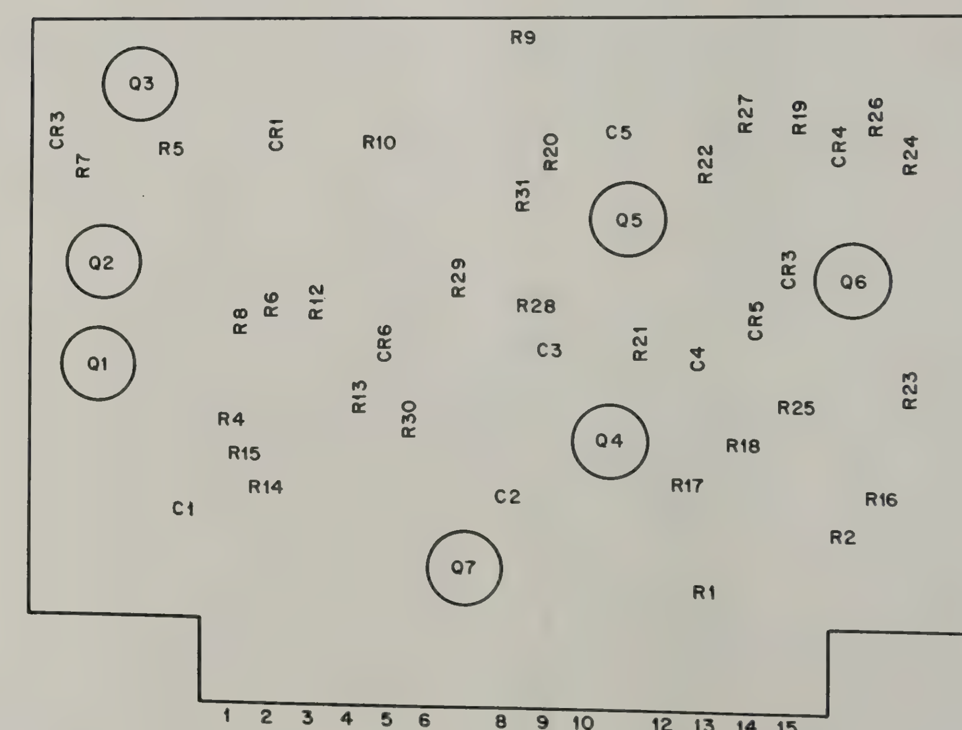
FIGURE 4.16





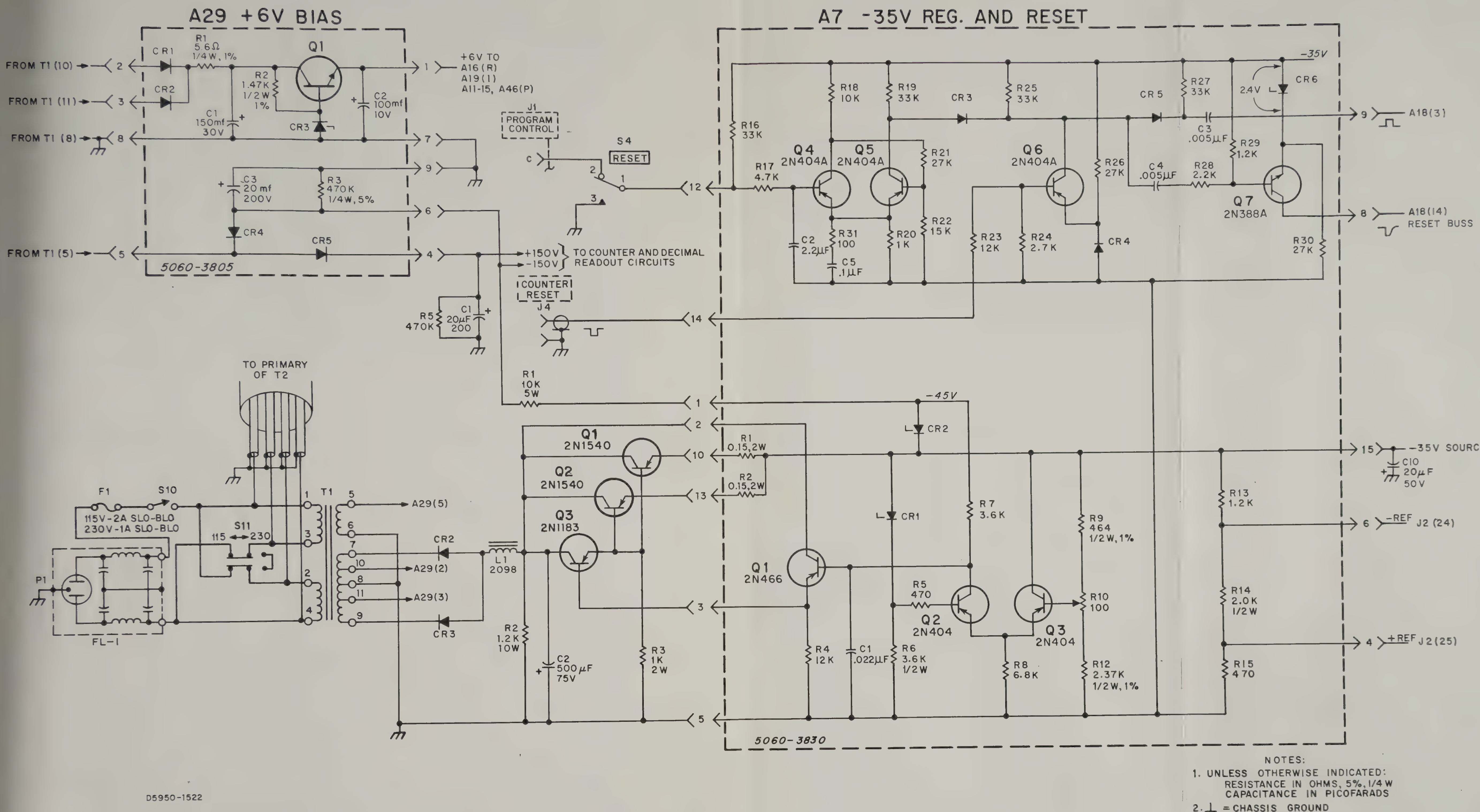
+6V BIAS CIRCUIT ASSEMBLY (A29)
5060-3805





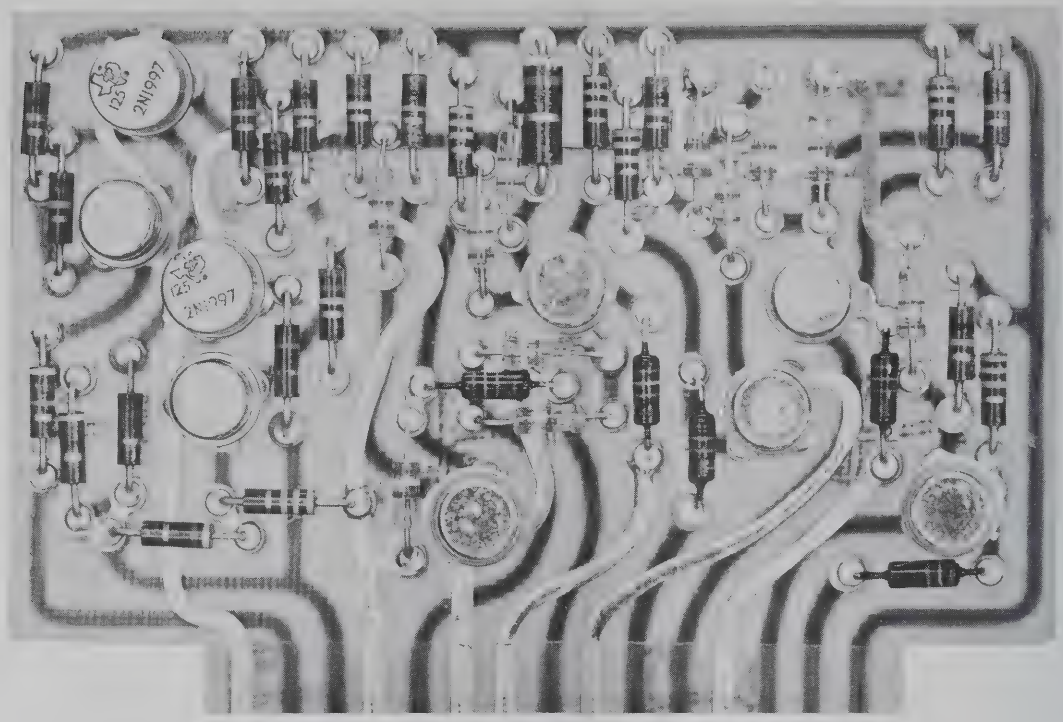
-35V REGULATOR AND RESET ASSEMBLY (A7)
5060-3830

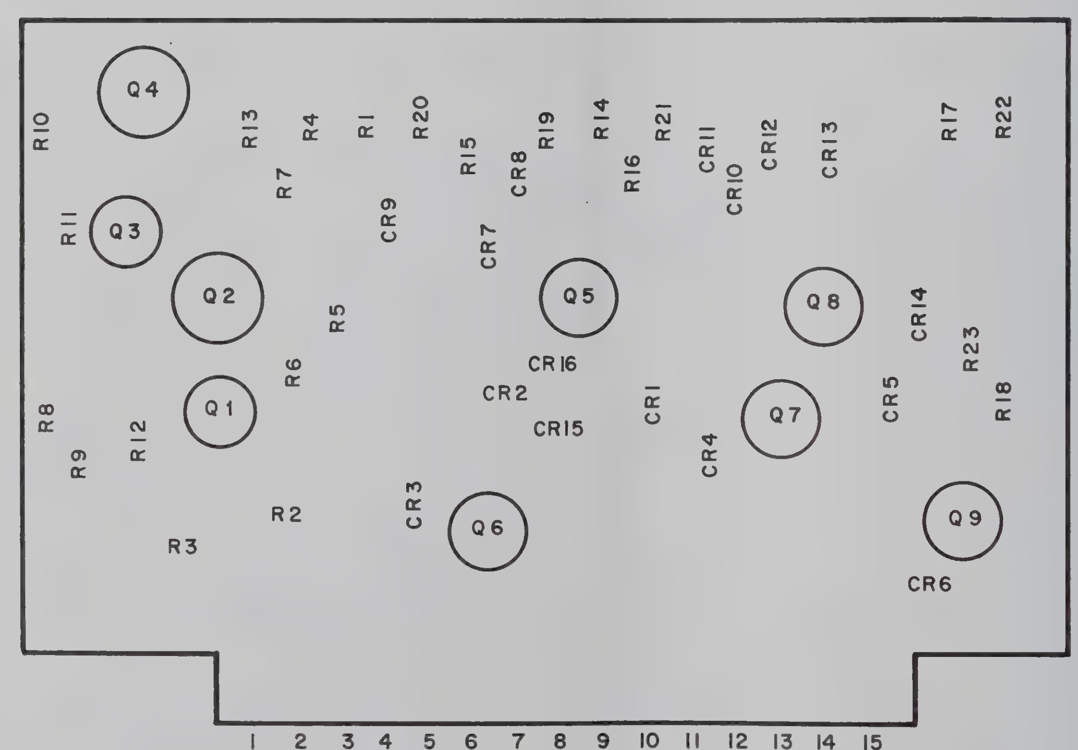
ASSEMBLIES A7 & A29
FIGURE 4.15



**-35V REGULATOR AND RESET CIRCUIT (A7)
AND +6V BIAS CIRCUIT (A29)**

FIGURE 4.16



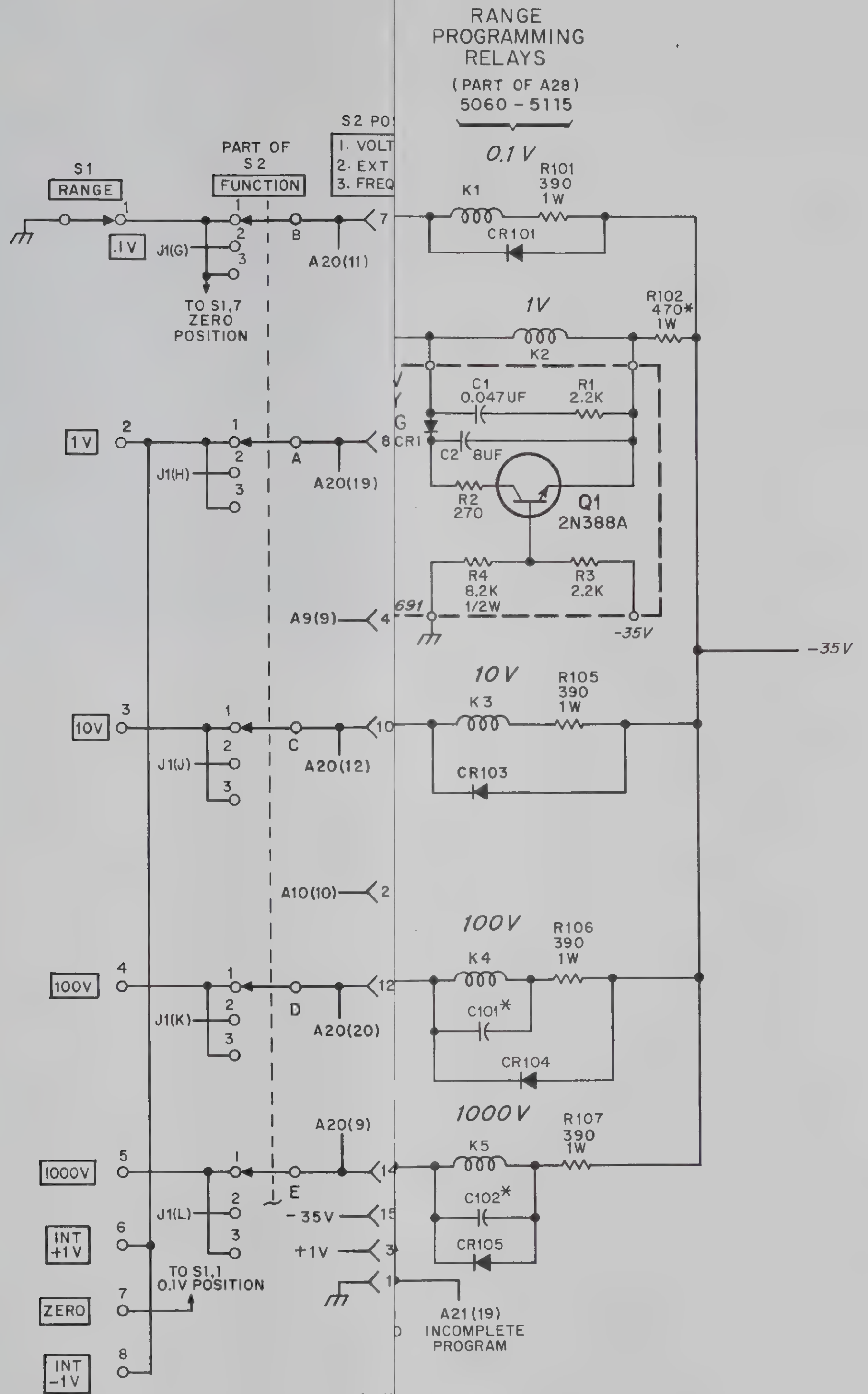


ATTENUATOR COUPLING LOGIC ASSEMBLY (A8)

5060-2014

ASSEMBLIES A8 & A47

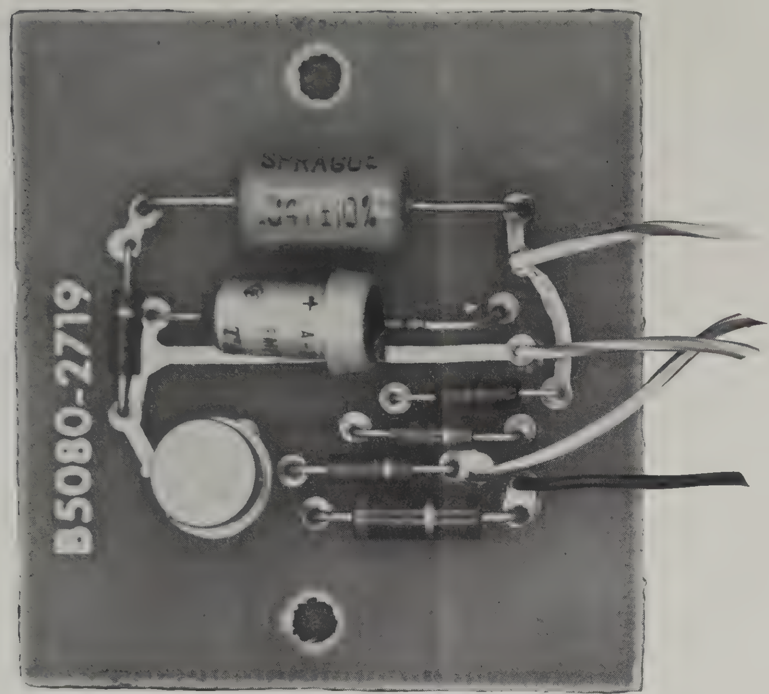
FIGURE 4.17

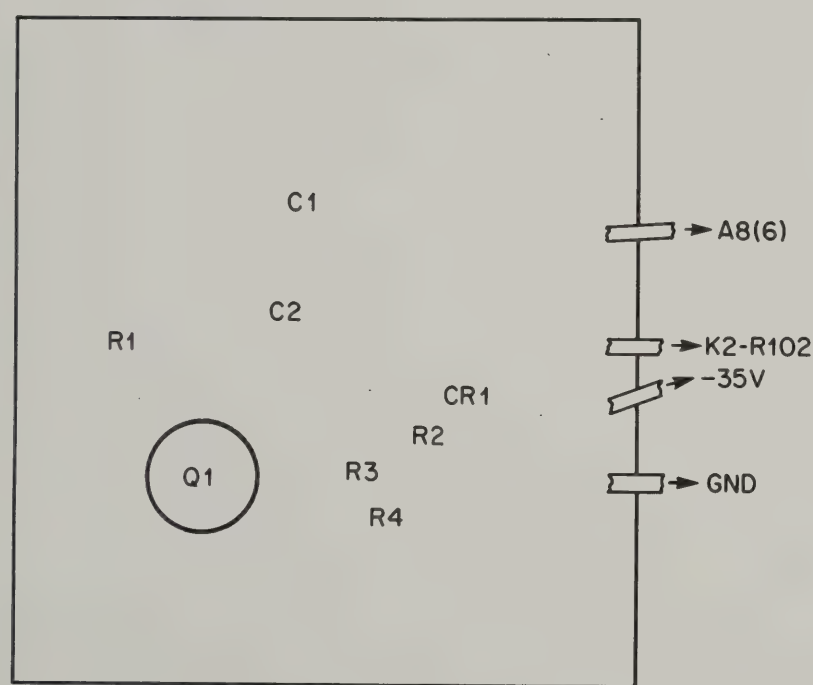


1. U
2. L
3. *
4. *

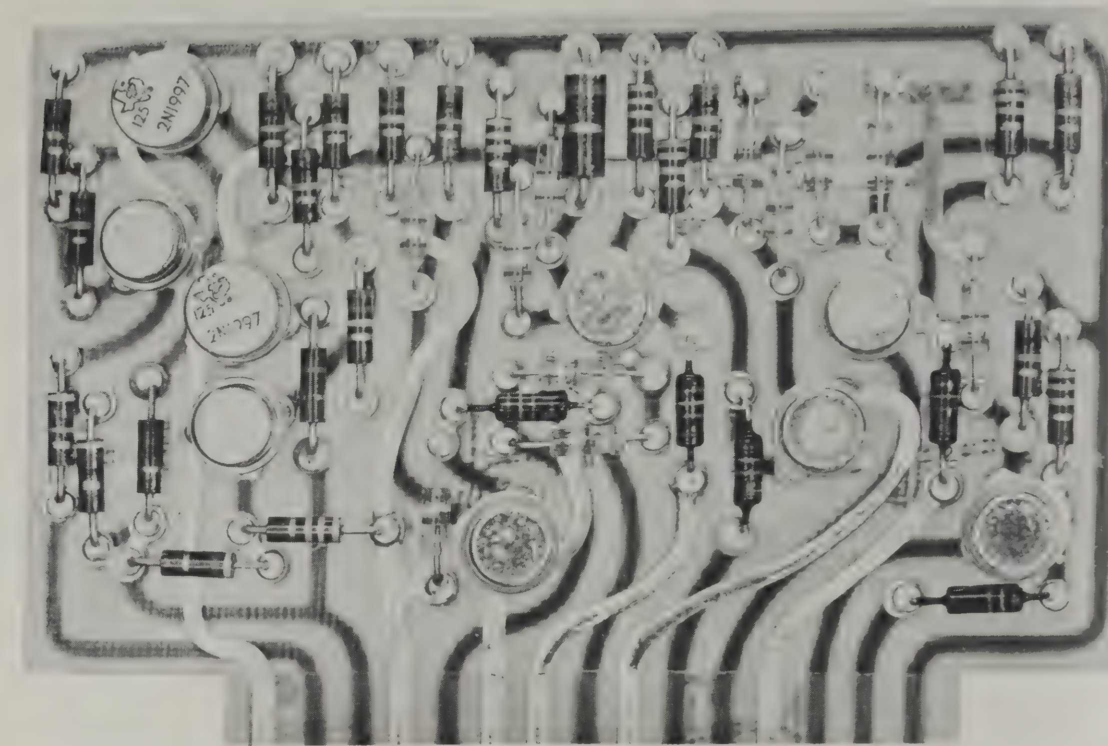
ATTENUATOR COUPLING CIRCUIT (A8)
AND 1V RELAY TIMING CIRCUIT (A47)

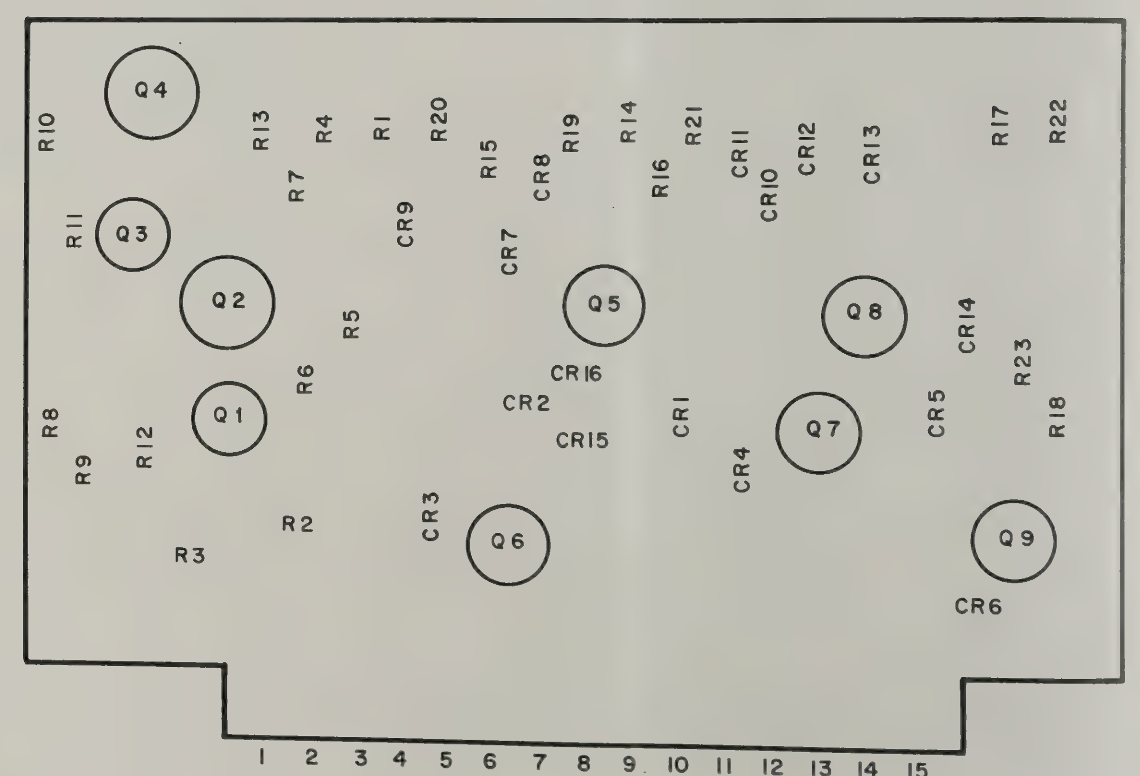
FIGURE 4.18





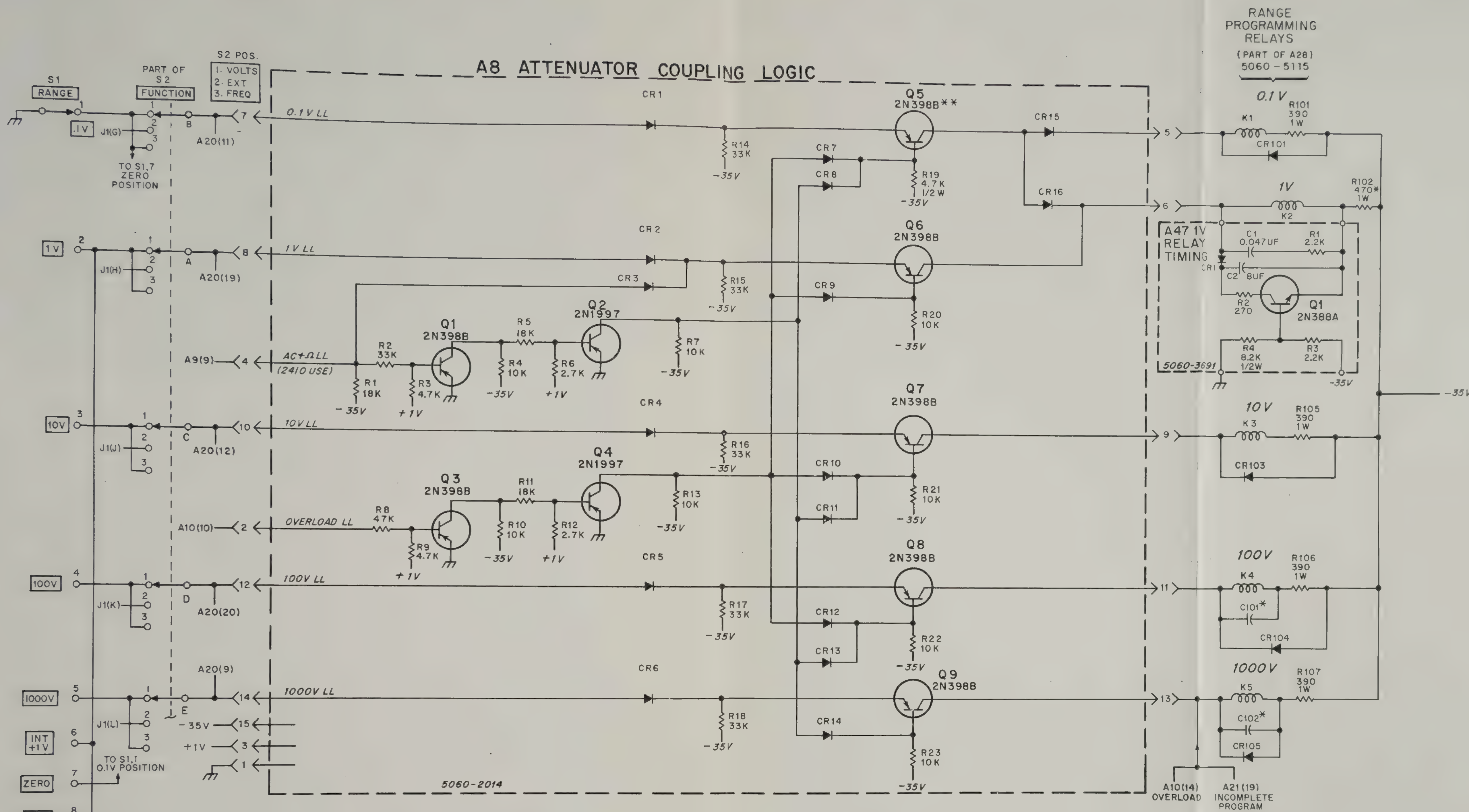
1V RELAY TIMING ASSEMBLY (A47)
5060-3691





ATTENUATOR COUPLING LOGIC ASSEMBLY (A8)
5060-2014

ASSEMBLIES A8 & A47
FIGURE 4.17

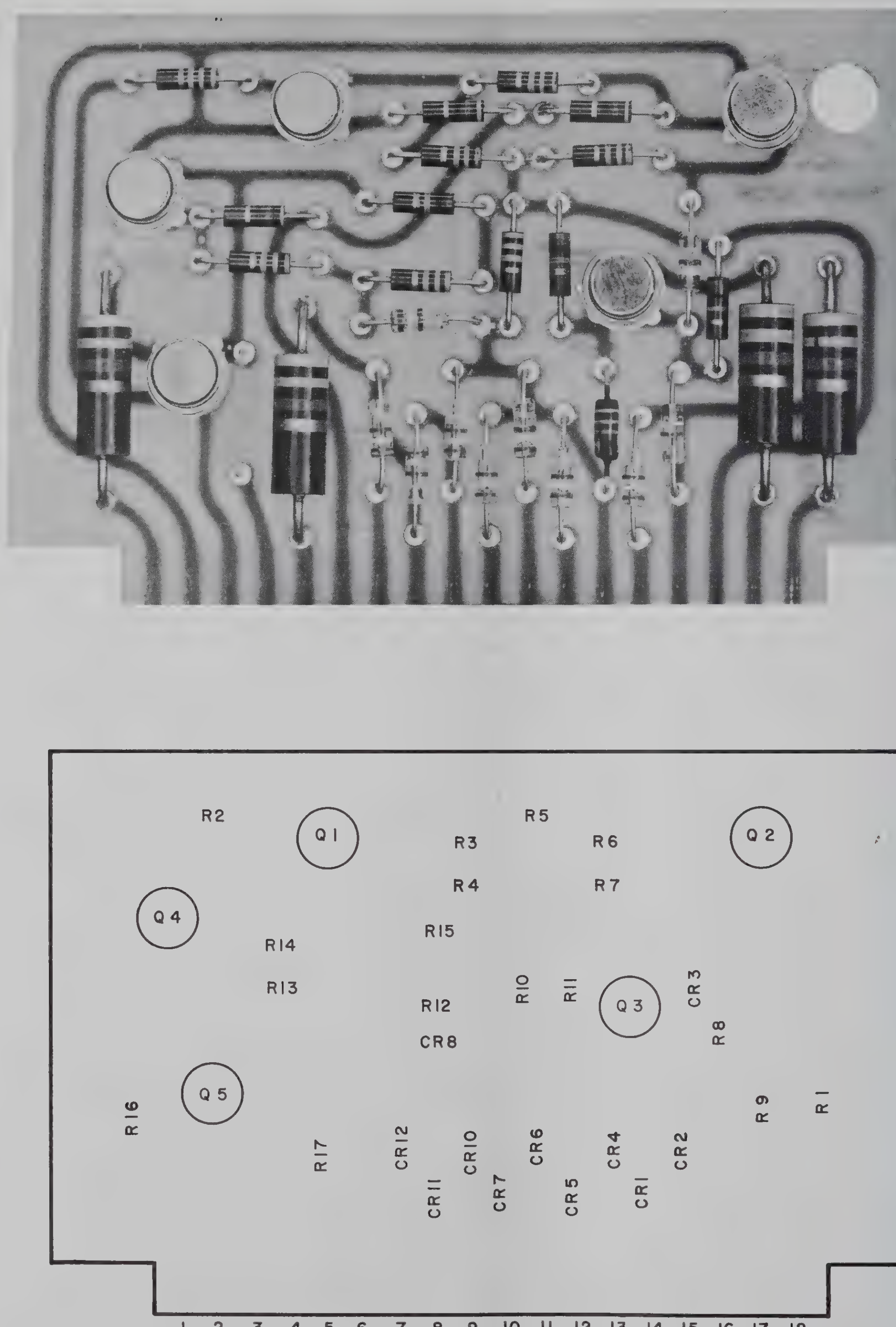


1. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS, 5%, 1/4W
   CAPACITANCE IN PICOFARADS
   DIODES ARE 1N292
2. LL = LOGIC LINE
3. * = FACTORY SELECTED VALUE.
4. ** = SPECIALLY SELECTED

D5950-1523

ATTENUATOR COUPLING CIRCUIT (A8) AND 1V RELAY TIMING CIRCUIT (A47)

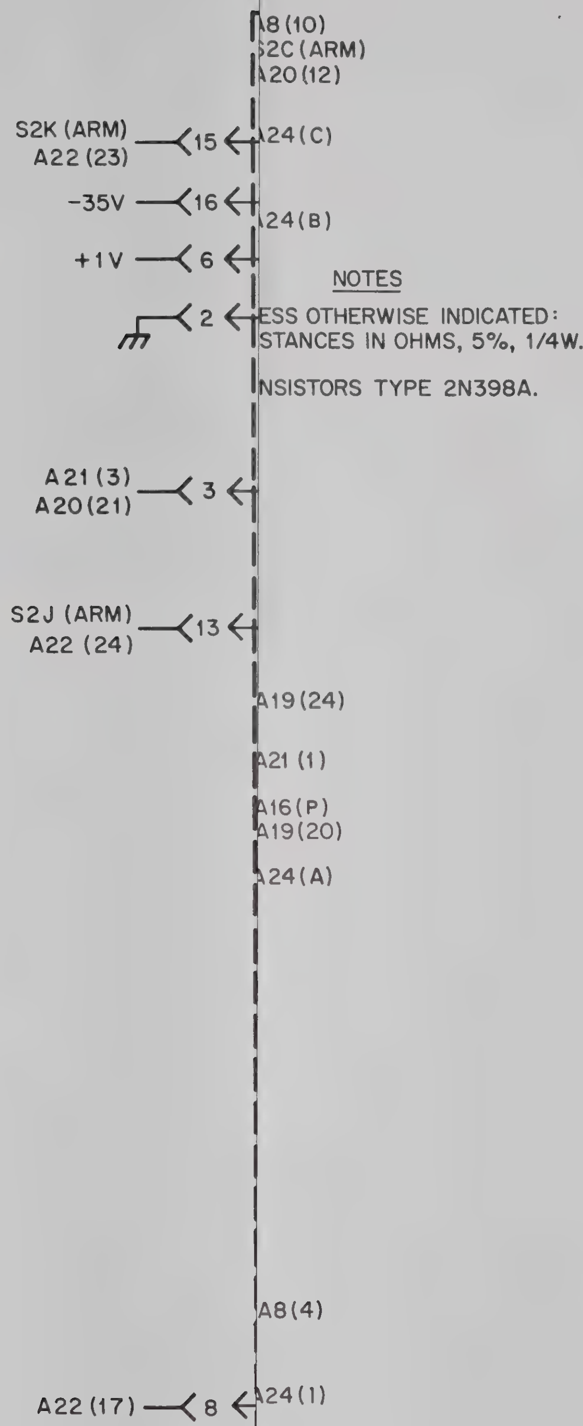
FIGURE 4.18



DY-2410B UNITS COUPLING CARD (A9)

5060-2015

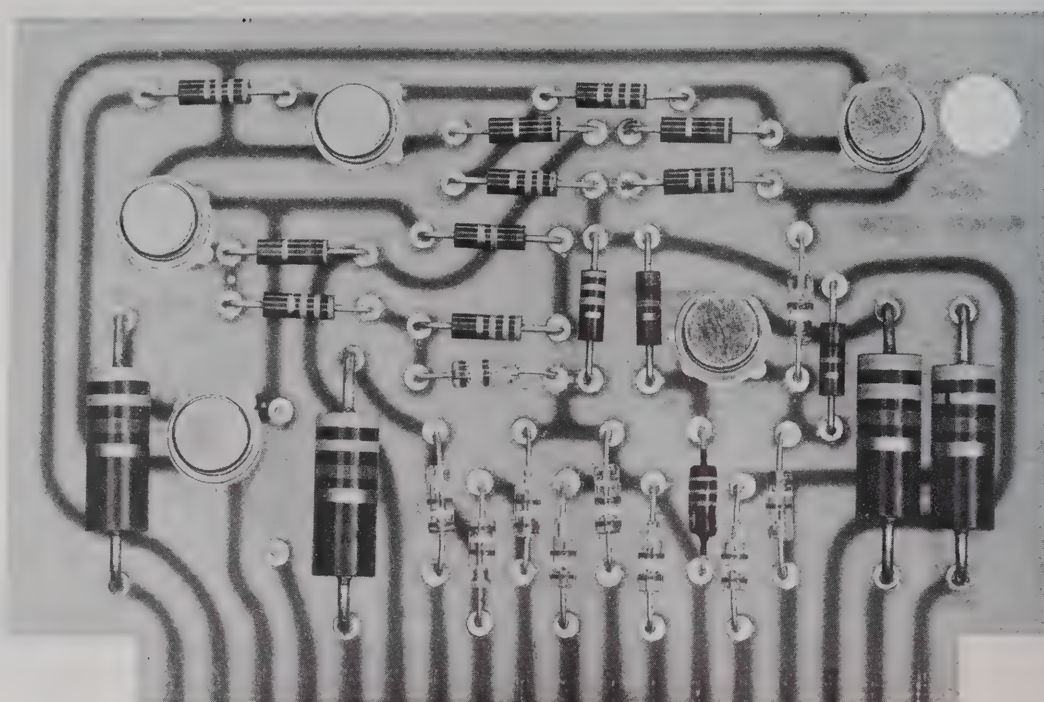
FIGURE 4.19

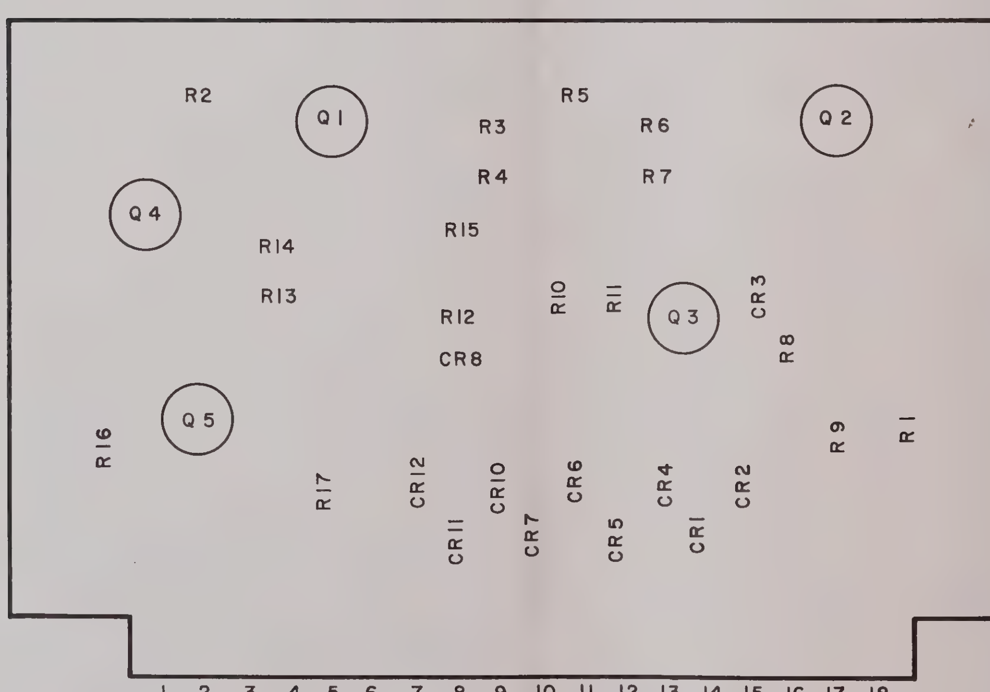


C5060-2015

DY-2410B UNITS COUPLING CIRCUIT (A9)

FIGURE 4.20

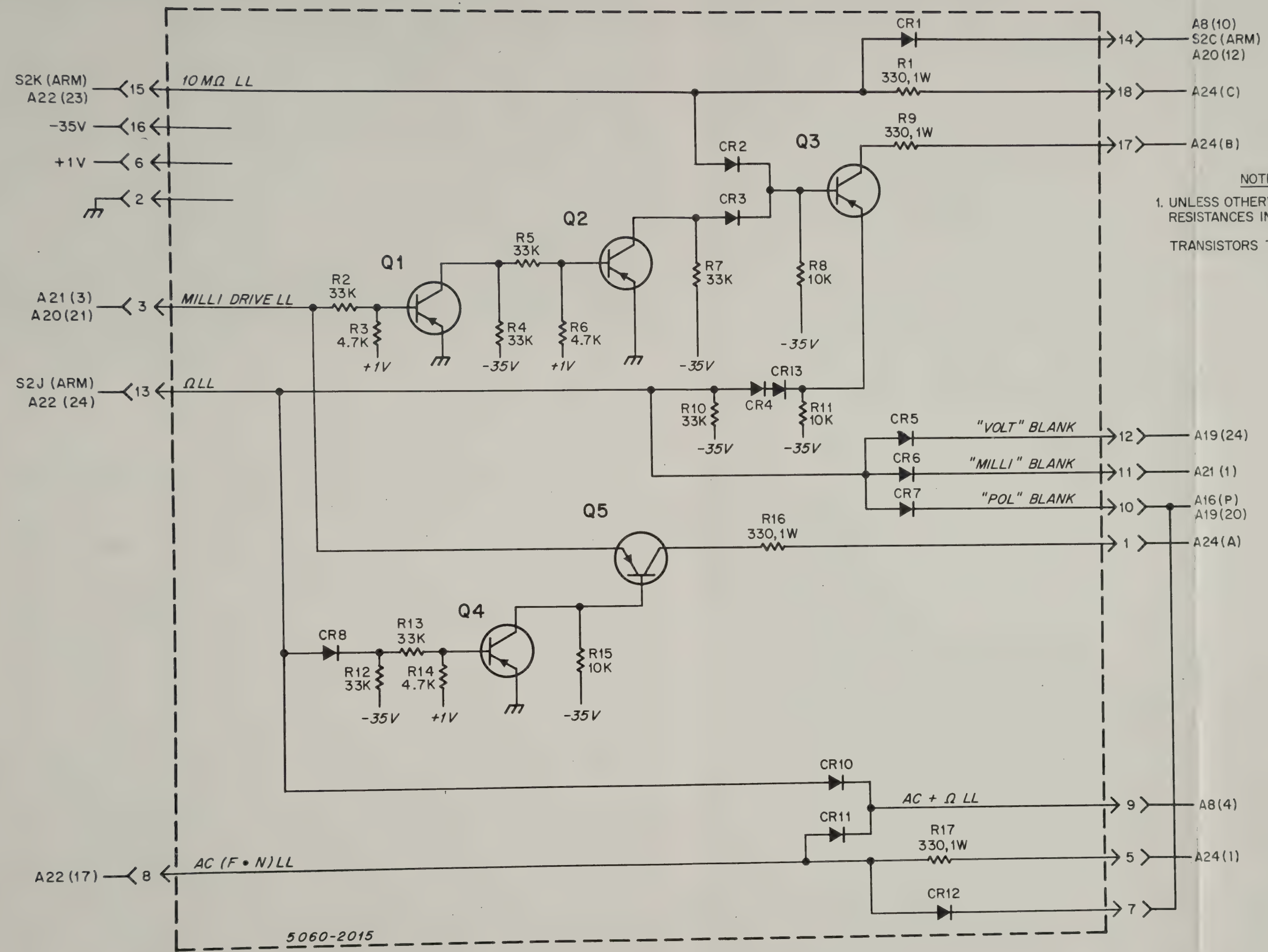




DY-2410B UNITS COUPLING CARD (A9)

5060-2015

FIGURE 4.19



NOTES

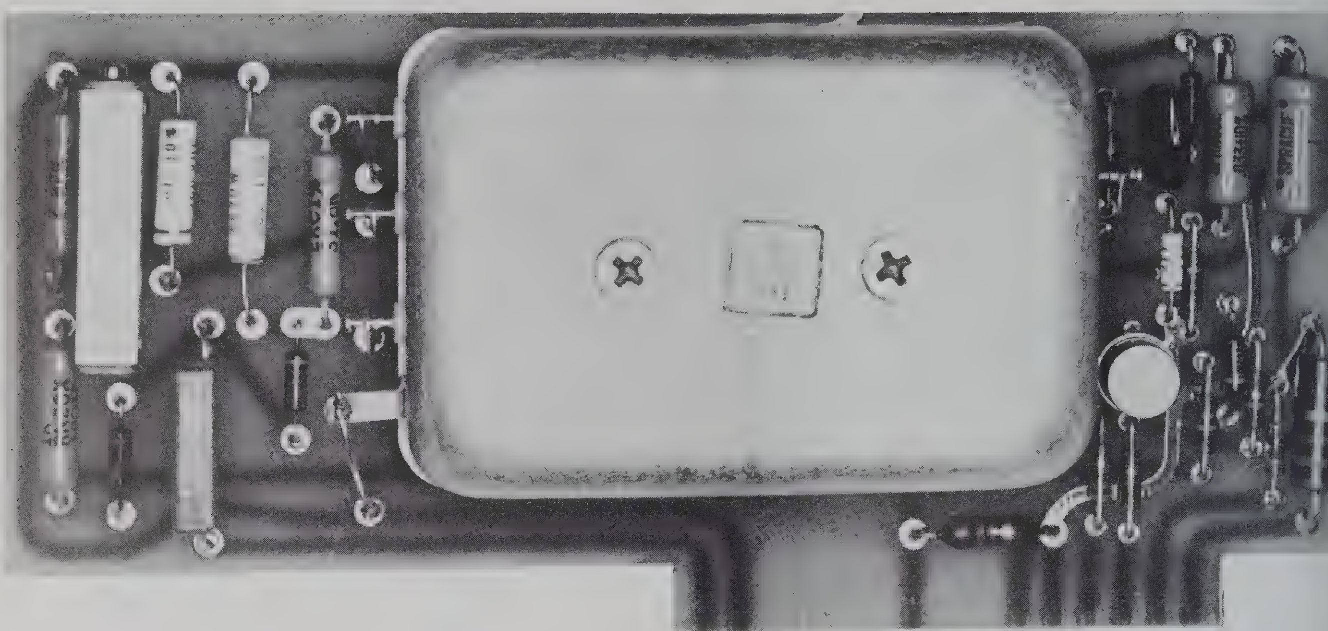
1. UNLESS OTHERWISE INDICATED: RESISTANCES IN OHMS, 5%, 1/4W.

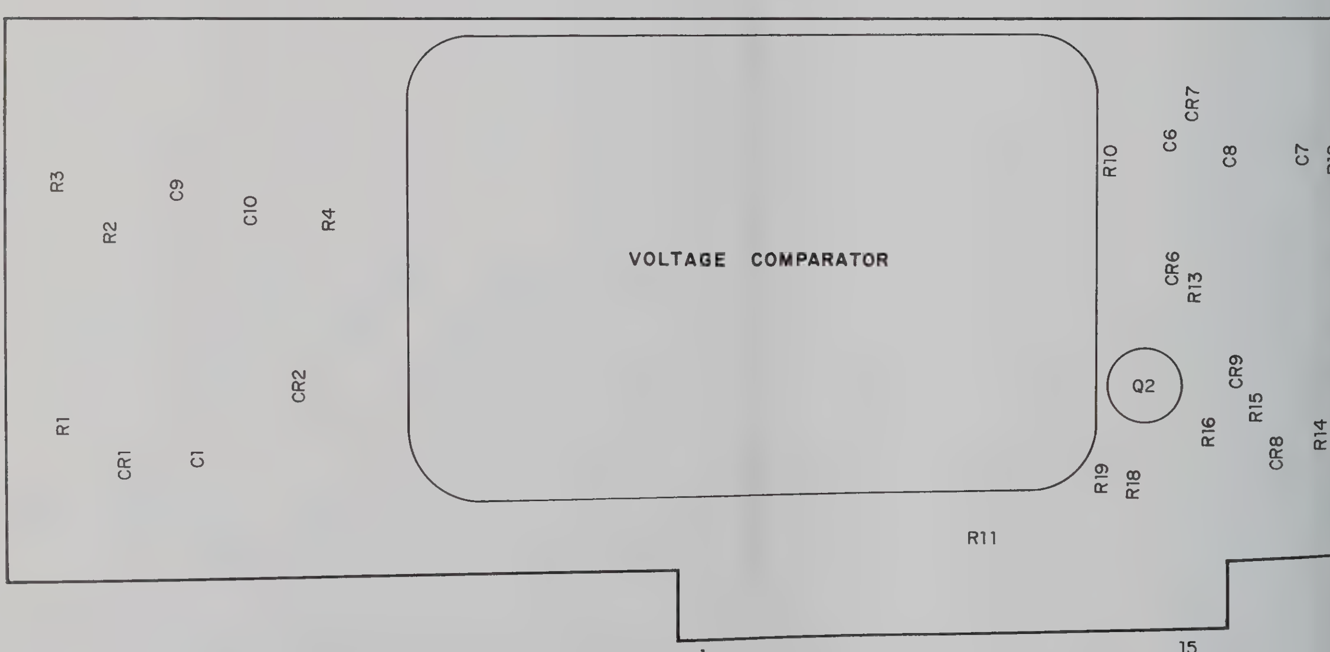
TRANSISTORS TYPE 2N398A.

C5060-2015

DY-2410B UNITS COUPLING CIRCUIT (A9)

FIGURE 4.20

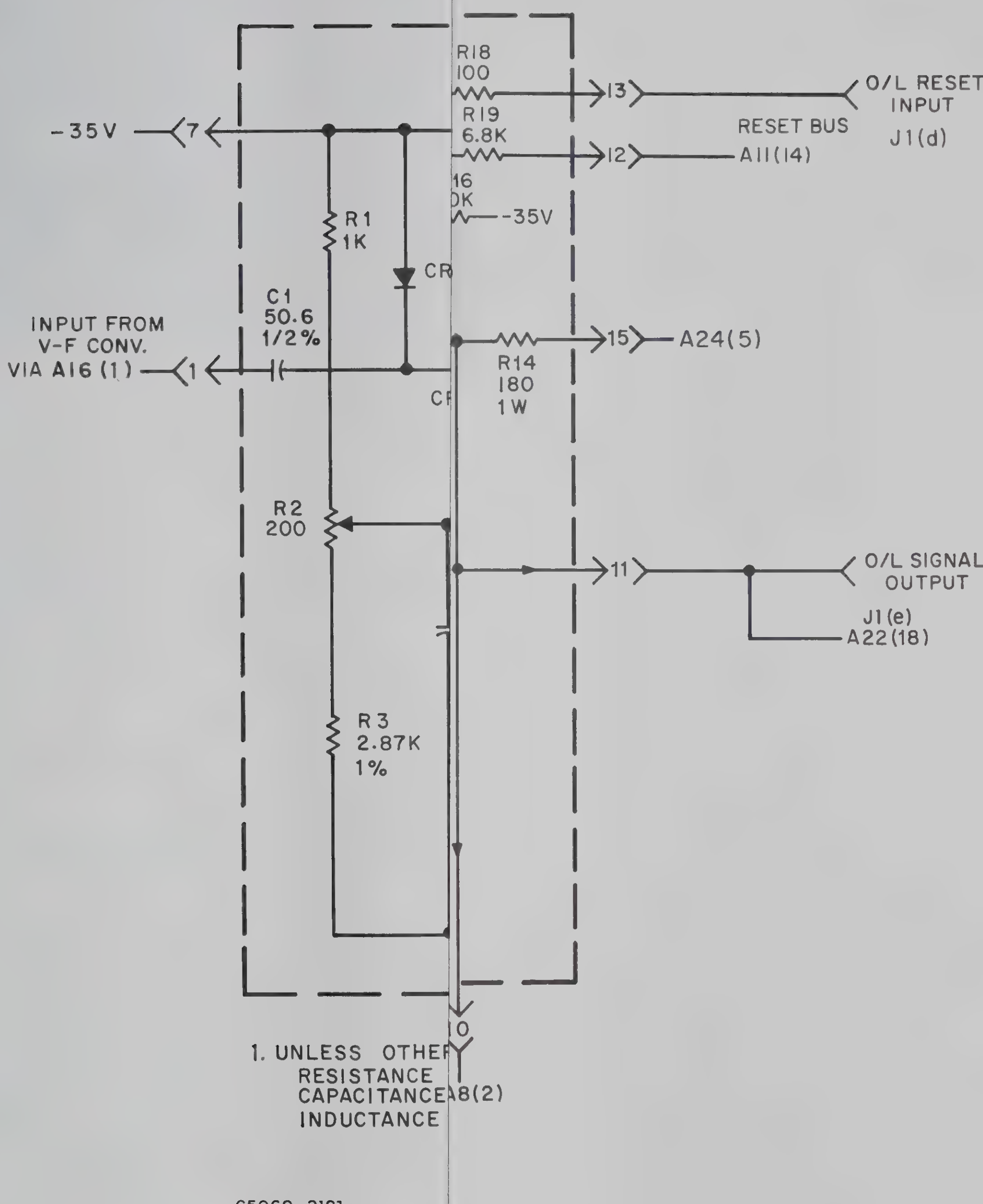




OVERLOAD DETECTOR ASSEMBLY (A10)

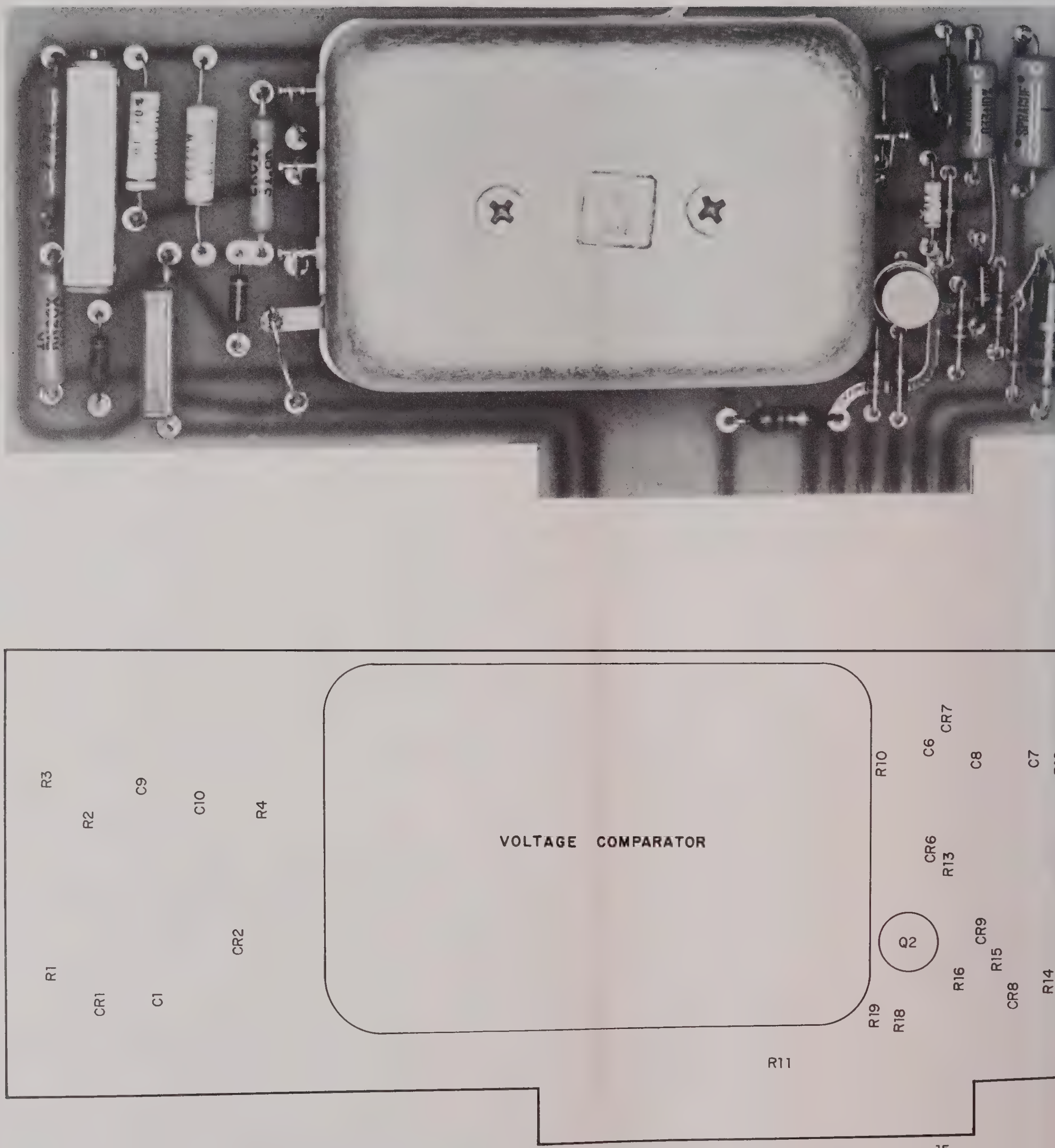
5060-2181

FIGURE 4.21



OVERLOAD DETECTOR CIRCUIT (A10)

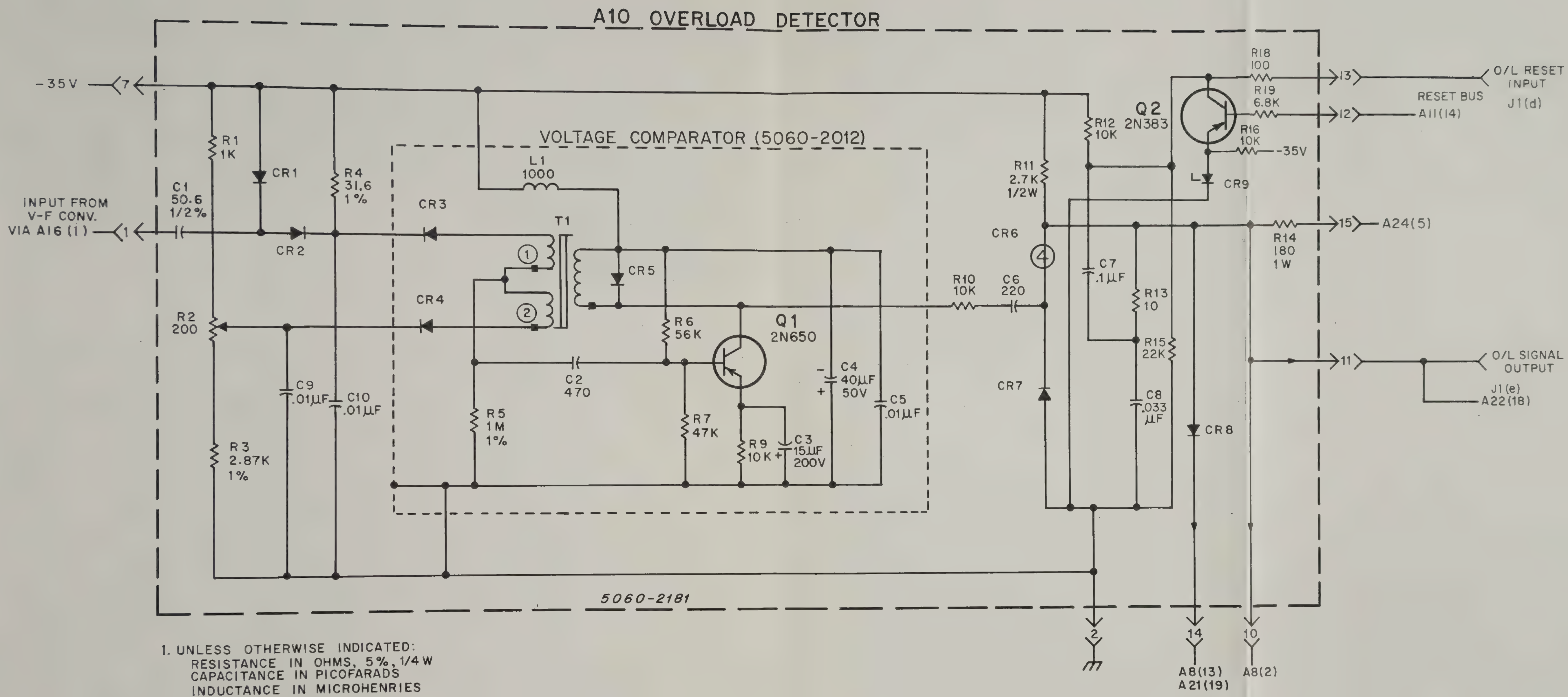
FIGURE 4.22



OVERLOAD DETECTOR ASSEMBLY (A10)

5060-2181

FIGURE 4.21

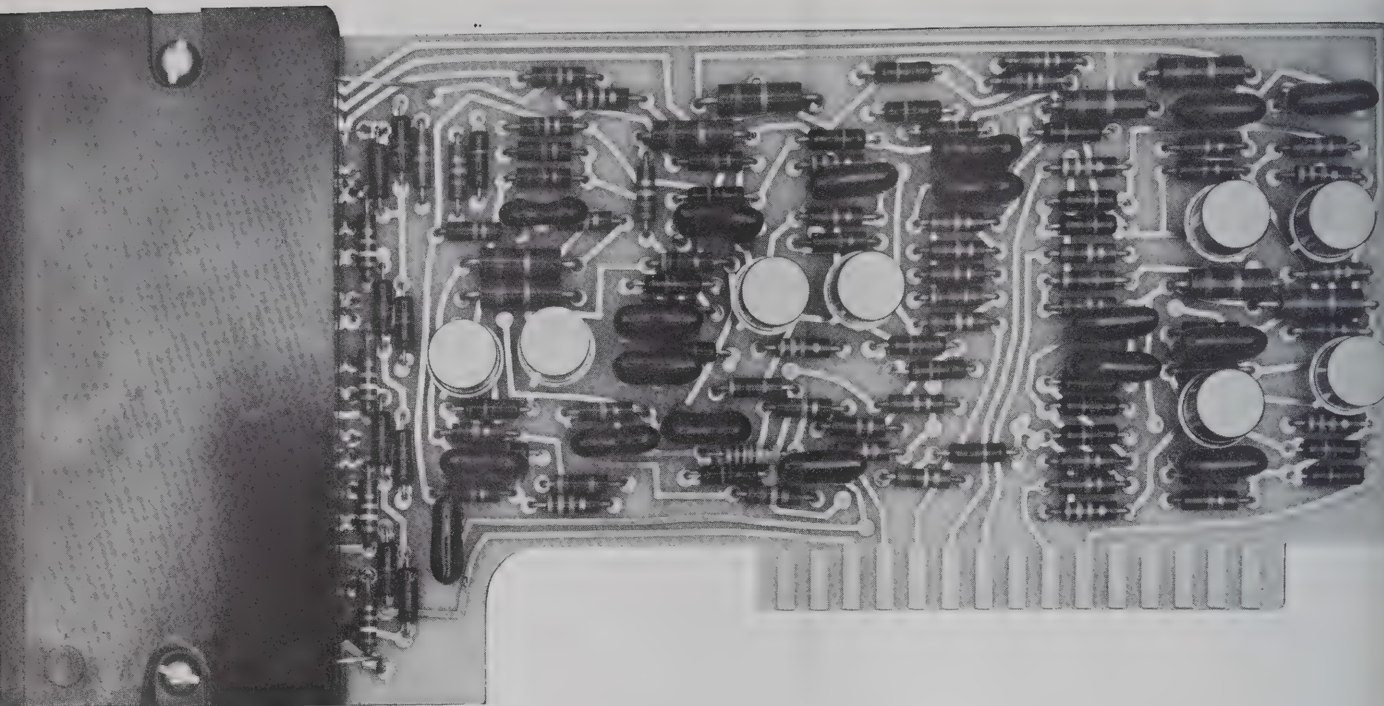


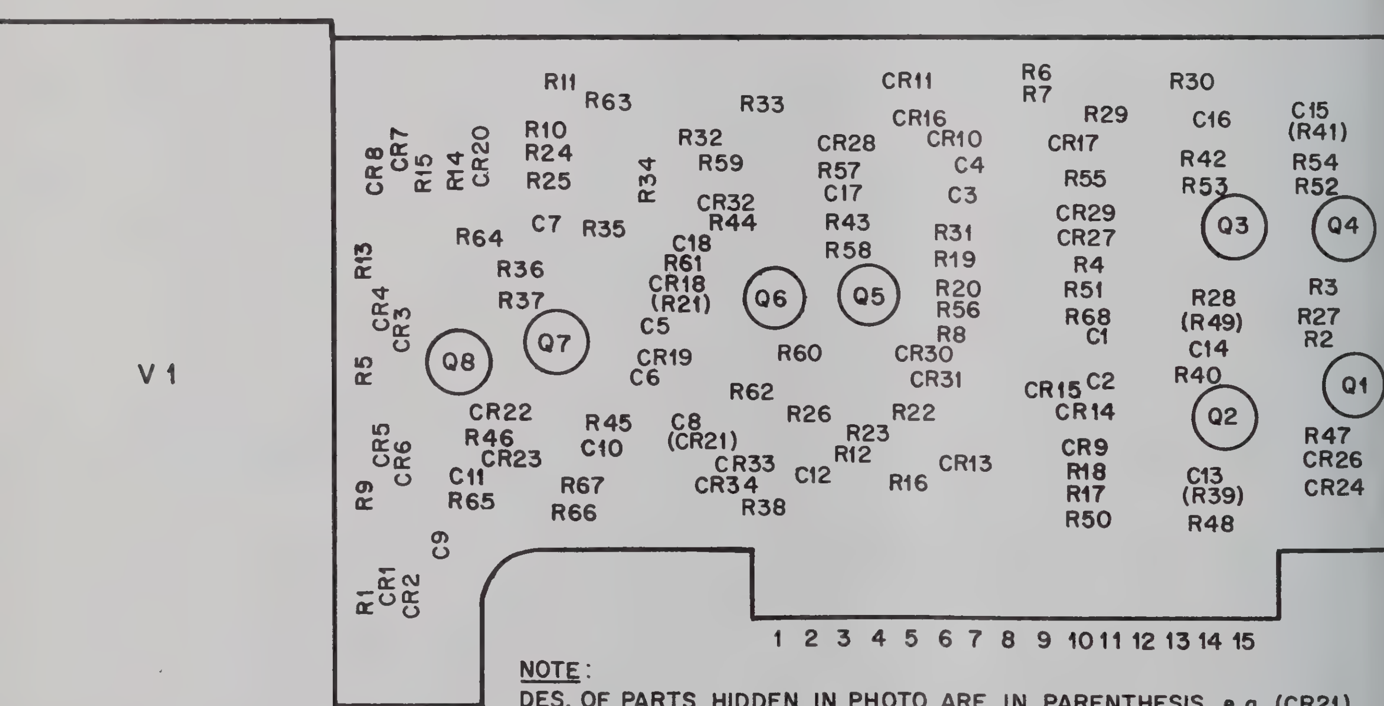
1. UNLESS OTHERWISE INDICATED:
RESISTANCE IN OHMS, 5%, 1/4 W
CAPACITANCE IN PICOFARADS
INDUCTANCE IN MICROHENRIES

C5060-2181

OVERLOAD DETECTOR CIRCUIT (A10)

FIGURE 4.22





REVERSIBLE 4-2'-2-1 DECADE COUNTER ASSEMBLY (A11-A15, A46)

5060-3781

FIGURE 4.23

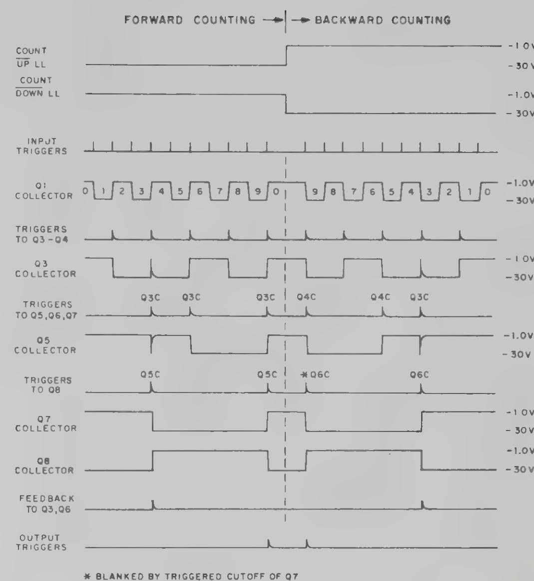
DIGIT	4 LINE CODE (0= −, 1= +)				RELEVANT STAGES	BINARY			
	D	C	B	A	V1	D	C	B	A
0	0	0	0	0	HPS				
1	0	0	0	1	DMR				
2	0	0	1	0	FNS				
3	0	0	1	1	BLR				
4	0	1	1	0	KQT				
5	0	1	1	1	JQT				
6	1	1	0	0	GPS				
7	1	1	0	1	CMR				
8	1	1	1	0	ENS				
9	1	1	1	1	ALR				

IN PARENTHESES
ON FOR DS1-DS4;
EAR EACH V1 SECT.

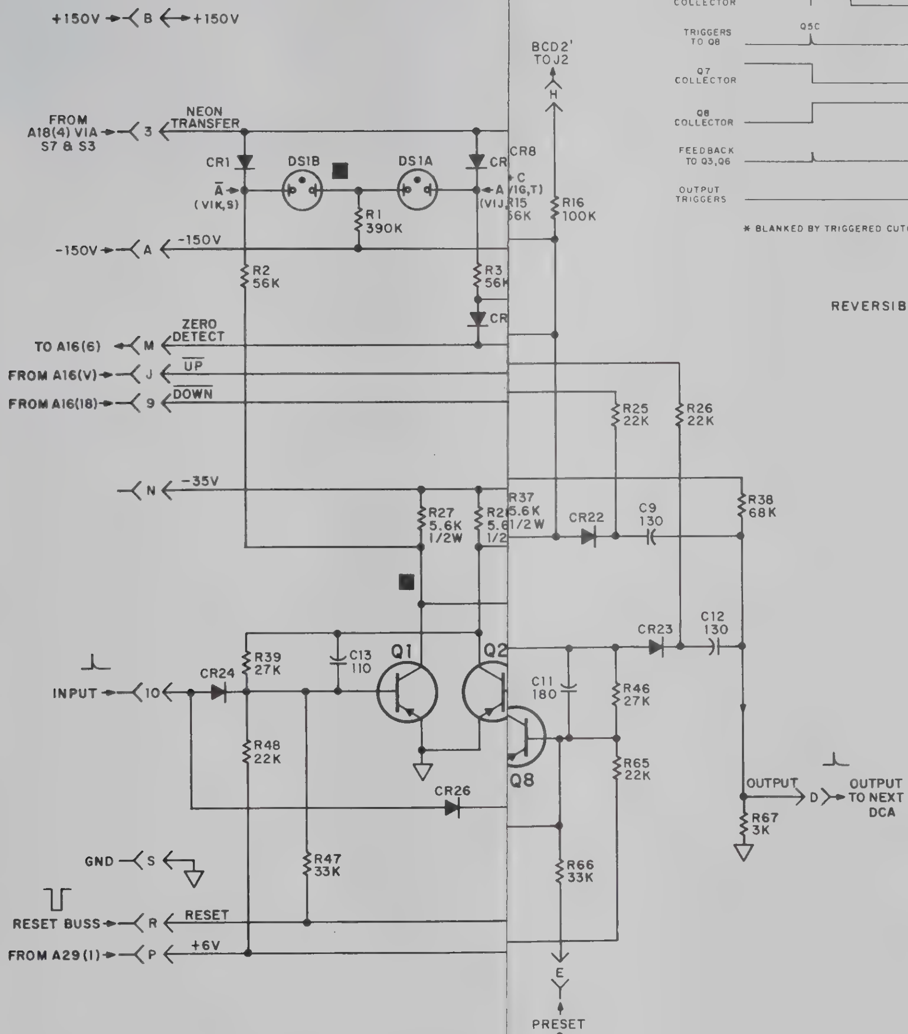
ATED:
S
OFARADS

HTS ON "1", SECTION

CATES CONDUCTING
" (BCD "0000")



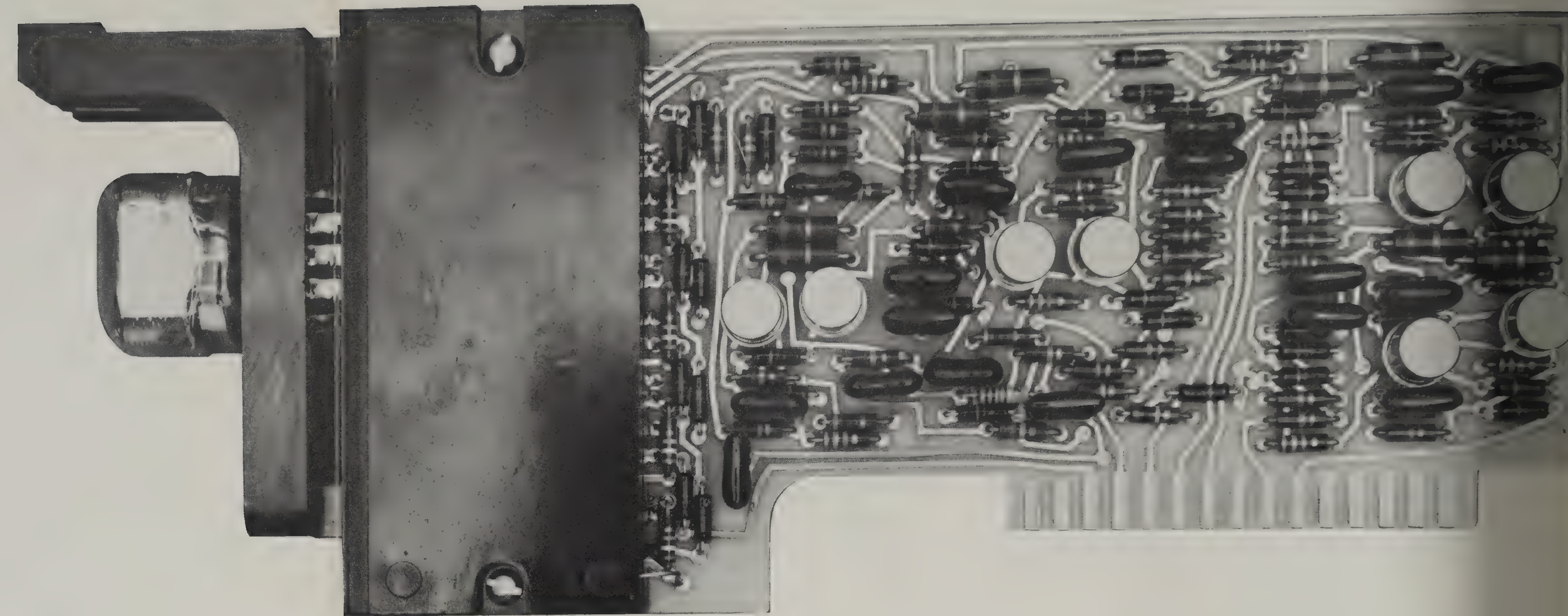
REVERSIBLE DECADE WAVEFORMS

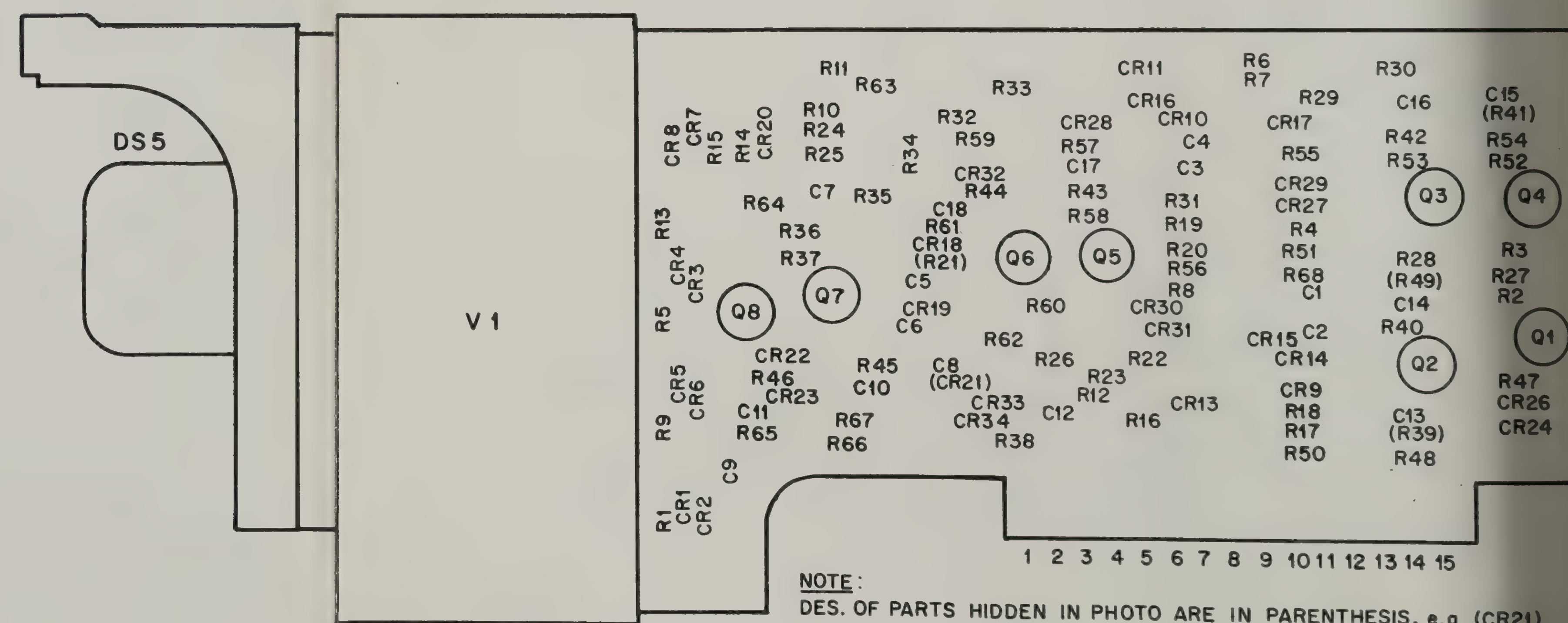


D5060-3781

REVERSIBLE 4-2'-2-1 DECADE COUNTER CIRCUIT (A11 - A15, A46)

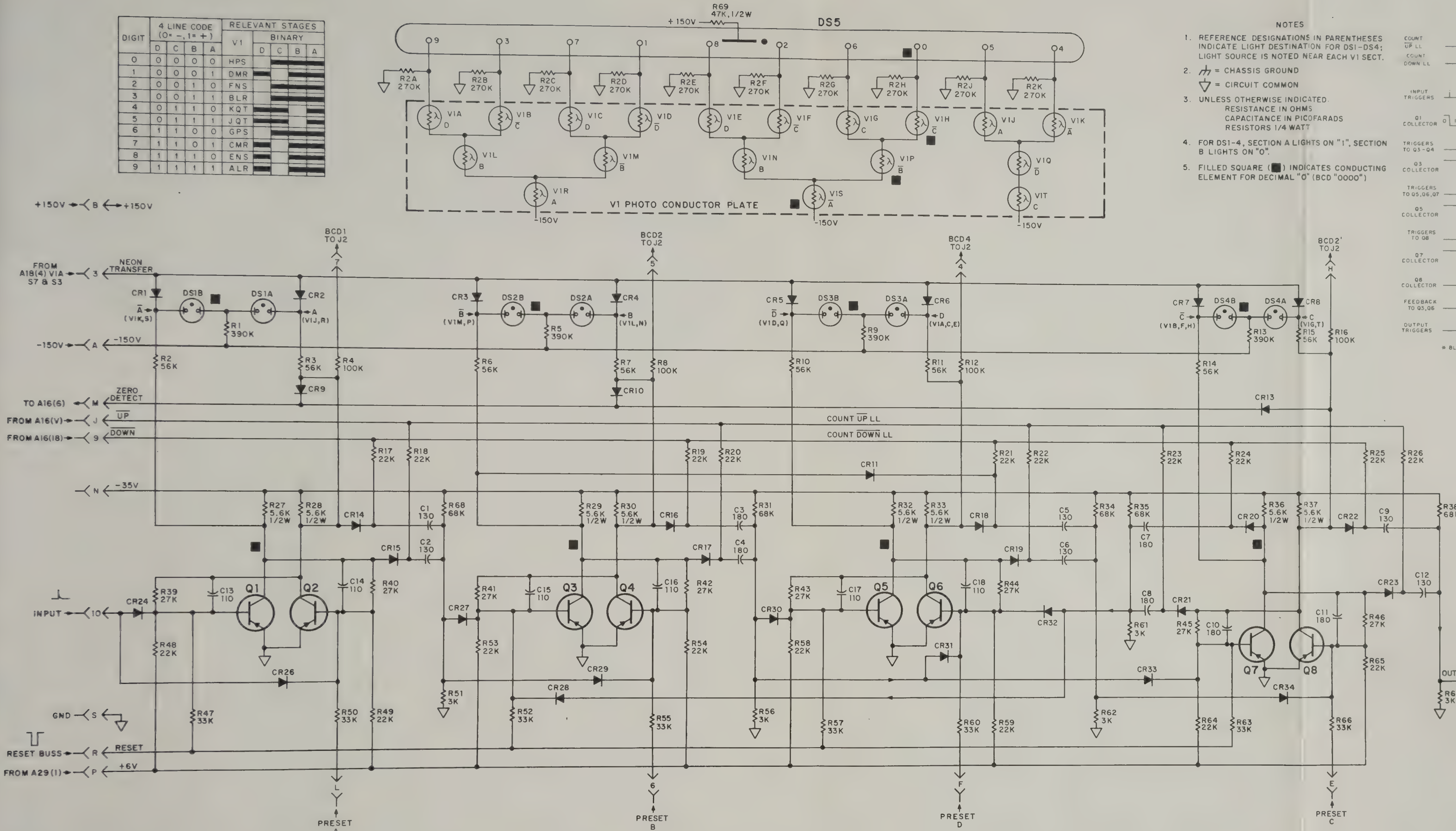
FIGURE 4.24





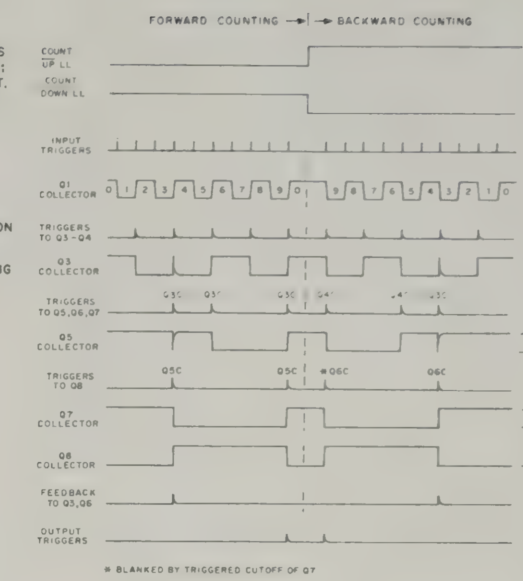
REVERSIBLE 4-2'-2-1 DECADE COUNTER
ASSEMBLY (A11-A15, A46)
5060-3781
FIGURE 4.23

DIGIT	4 LINE CODE (0= −, 1= +)				RELEVANT STAGES				
					V1	BINARY			
	D	C	B	A		D	C	B	A
0	0	0	0	0	HPS				
1	0	0	0	1	DMR				
2	0	0	1	0	FNS				
3	0	0	1	1	BLR				
4	0	1	1	0	KQT				
5	0	1	1	1	JQT				
6	1	1	0	0	GPS				
7	1	1	0	1	CMR				
8	1	1	1	0	ENS				
9	1	1	1	1	ALR				



NOTES

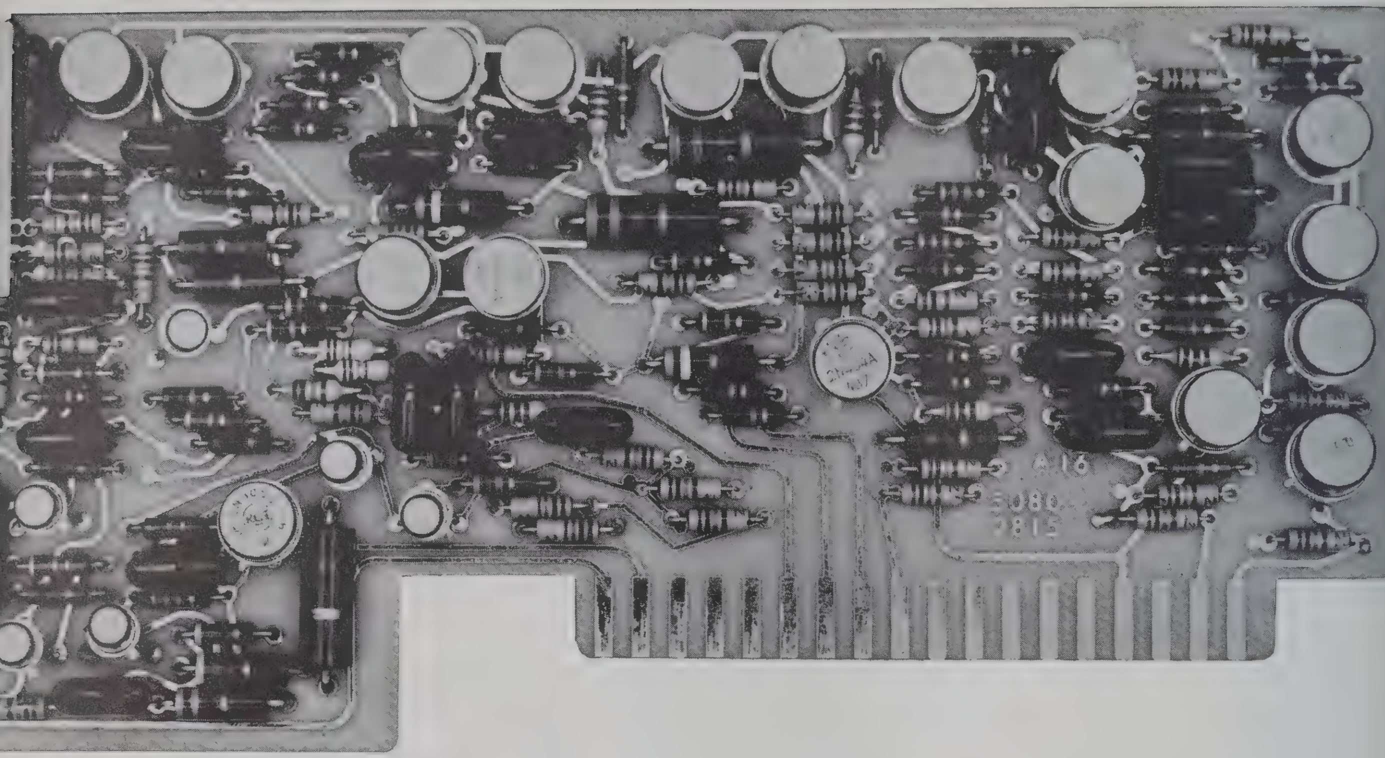
1. REFERENCE DESIGNATIONS IN PARENTHESES INDICATE LIGHT DESTINATION FOR DS1-DS4; LIGHT SOURCE IS NOTED NEAR EACH V1 SECT.
2. = CHASSIS GROUND
   = CIRCUIT COMMON
3. UNLESS OTHERWISE INDICATED.
   RESISTANCE IN OHMS
   CAPACITANCE IN PICOFARADS
   RESISTORS 1/4 WATT
4. FOR DS1-4, SECTION A LIGHTS ON "1", SECTION B LIGHTS ON "0".
5. FILLED SQUARE (■) INDICATES CONDUCTING ELEMENT FOR DECIMAL "0" (BCD "0000")

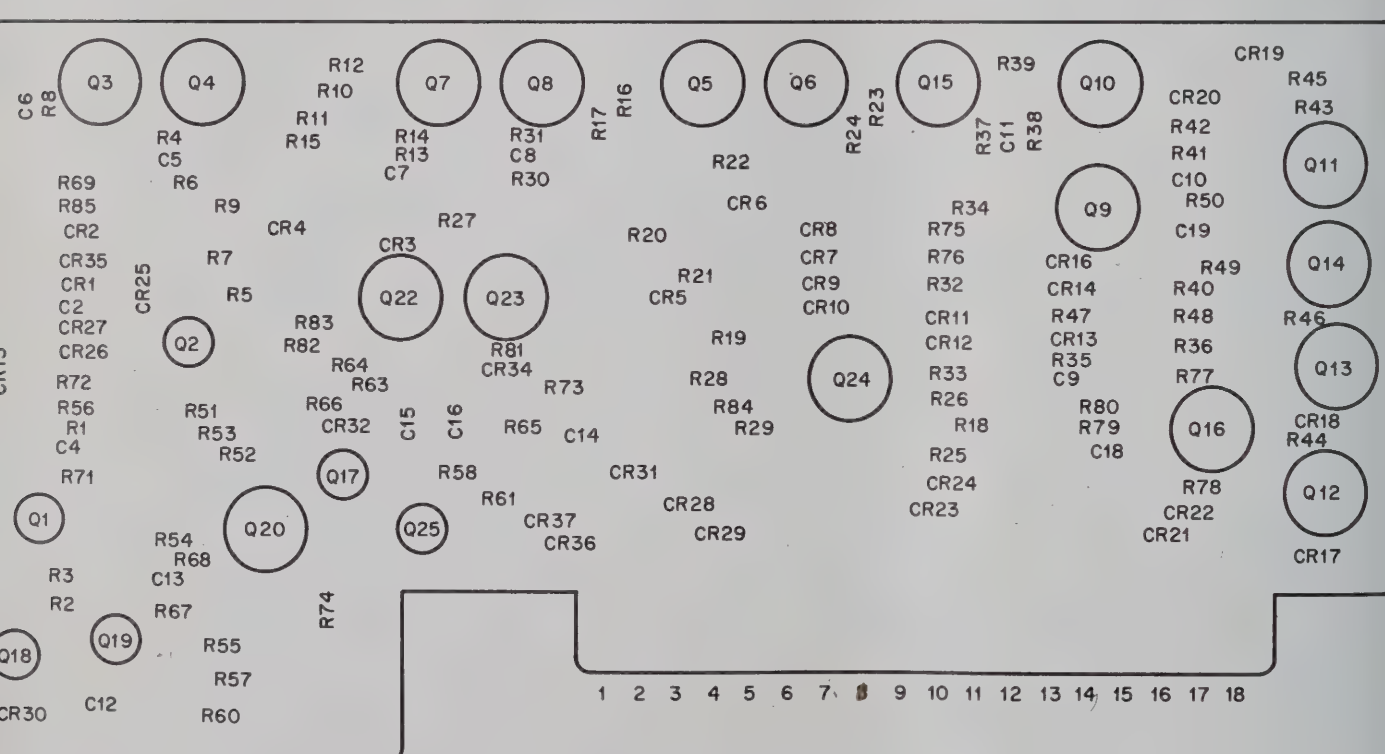


REVERSIBLE DECADE WAVEFORMS

REVERSIBLE 4-2'-2-1 DECADE COUNTER CIRCUIT (A11 - A15, A46)

FIGURE 4.24

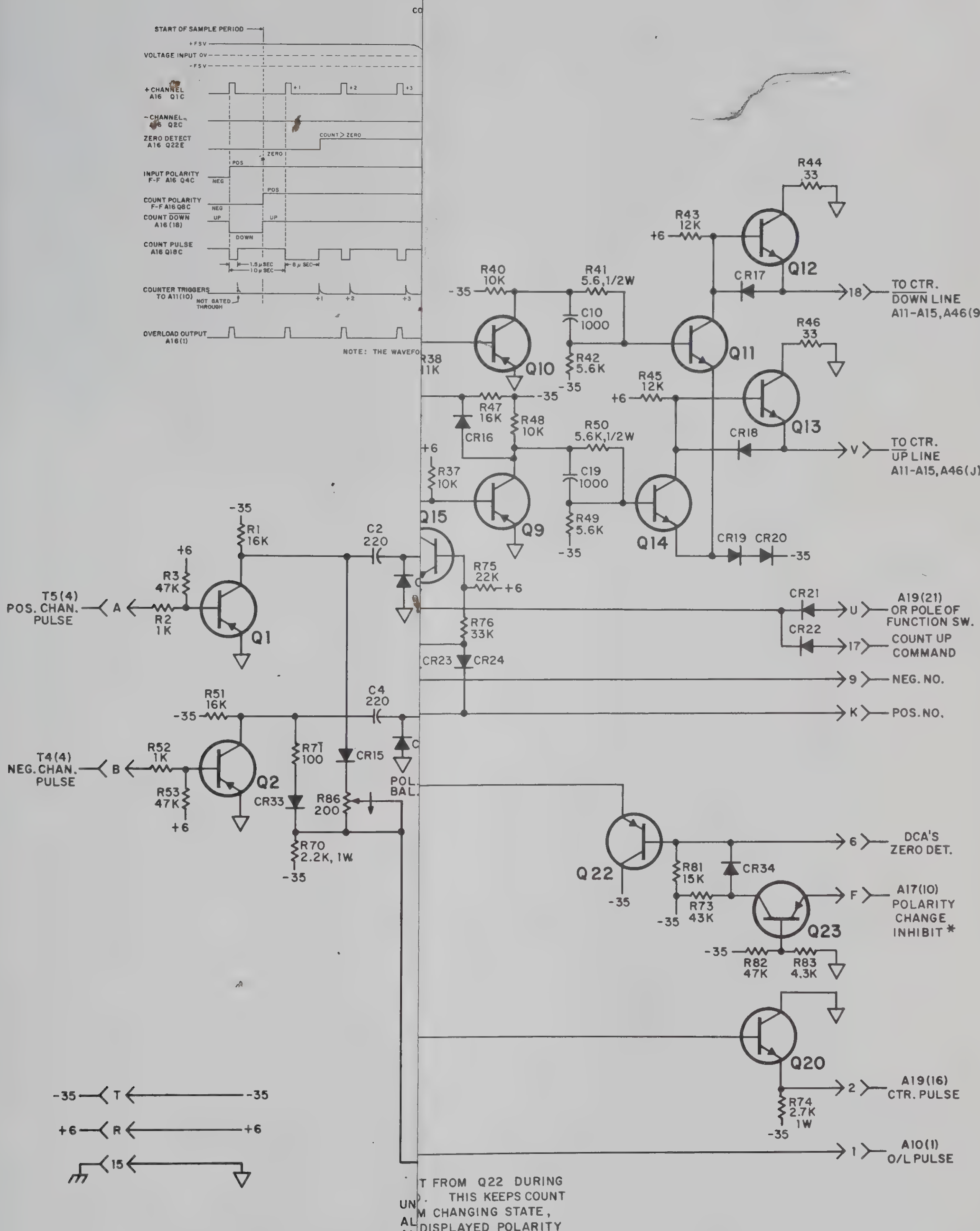




COUNTER CONTROL ASSEMBLY (A16)

5060-3809

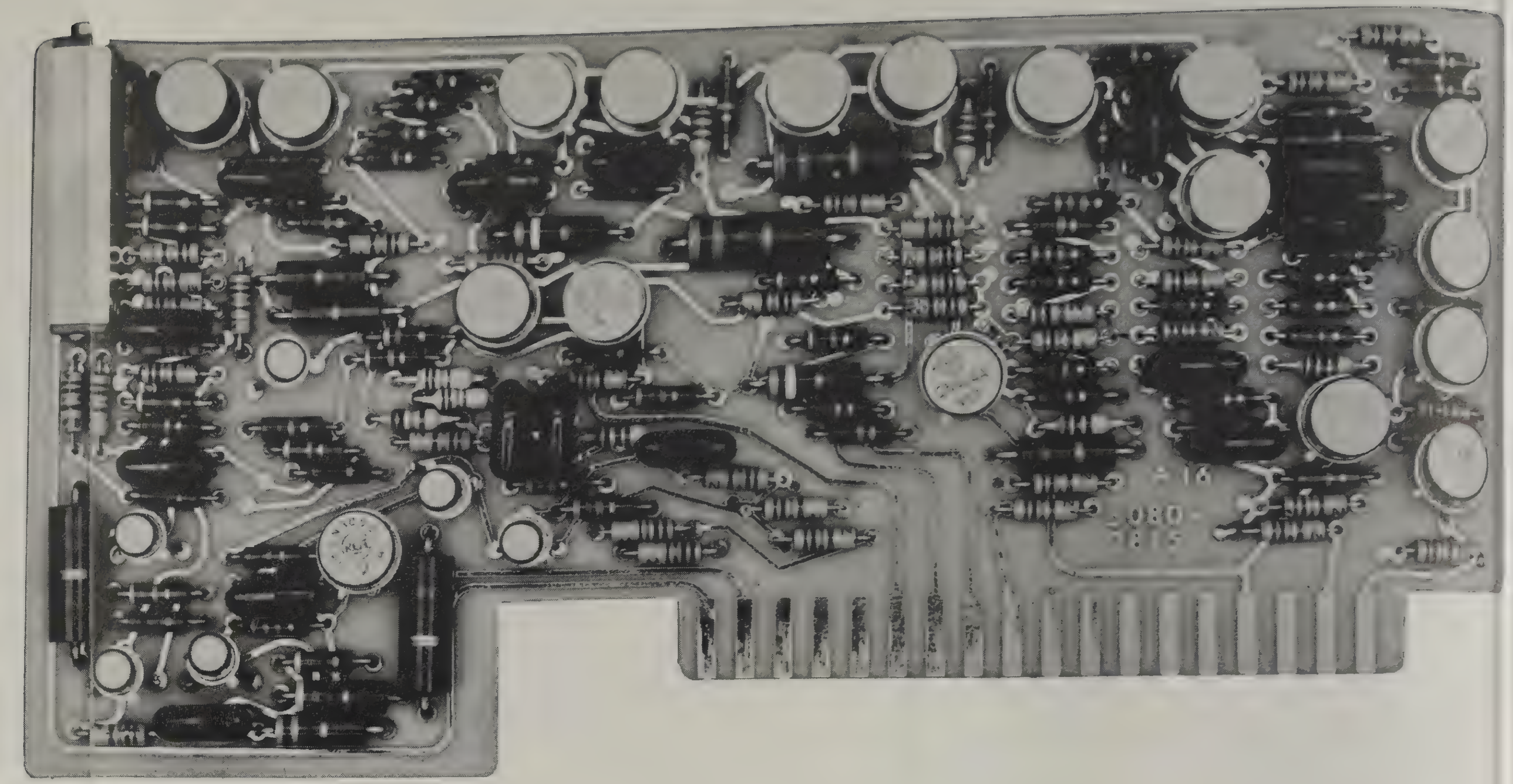
FIGURE 4.25

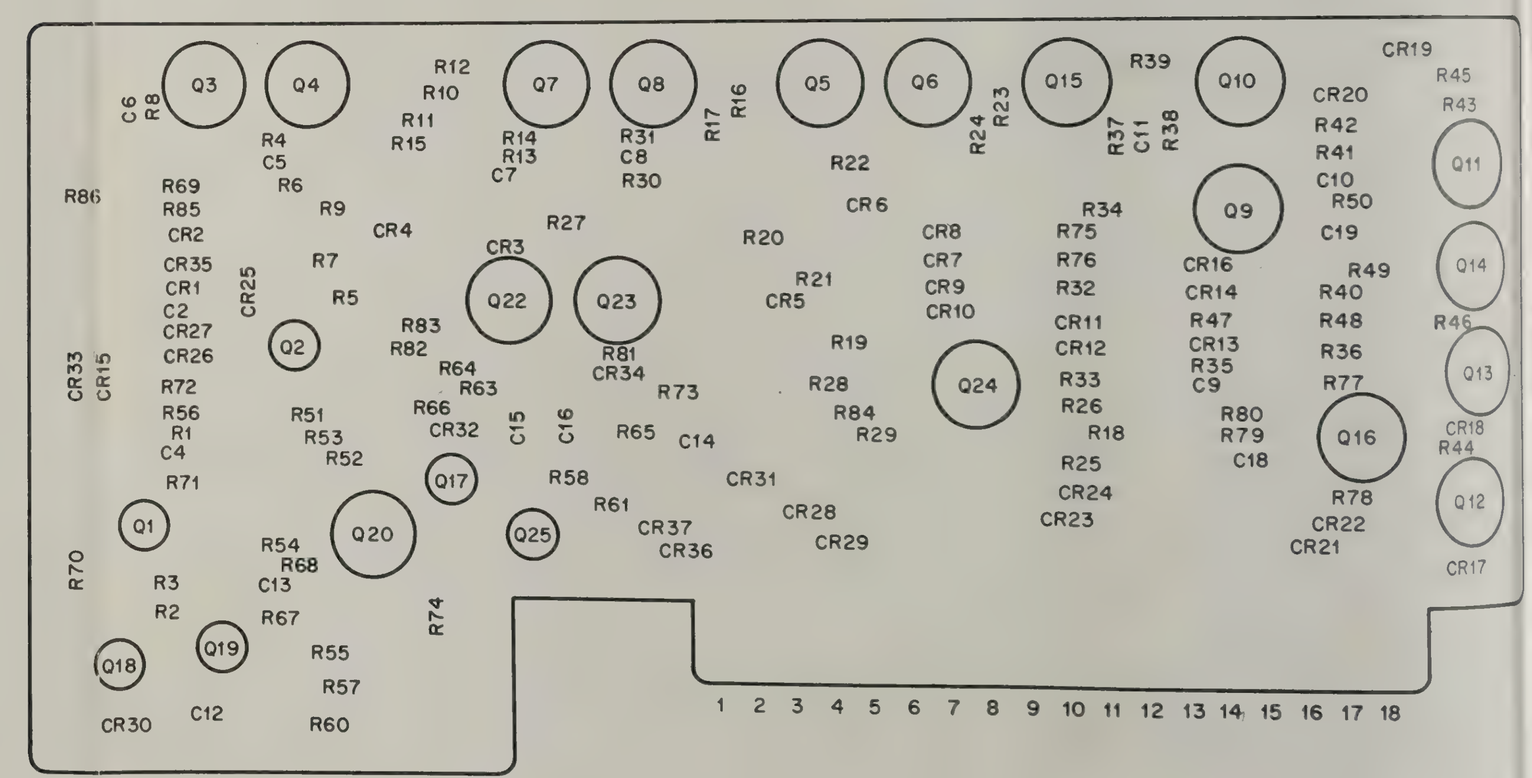


D5060-3809

COUNTER CONTROL CIRCUIT (A16)

FIGURE 4.26

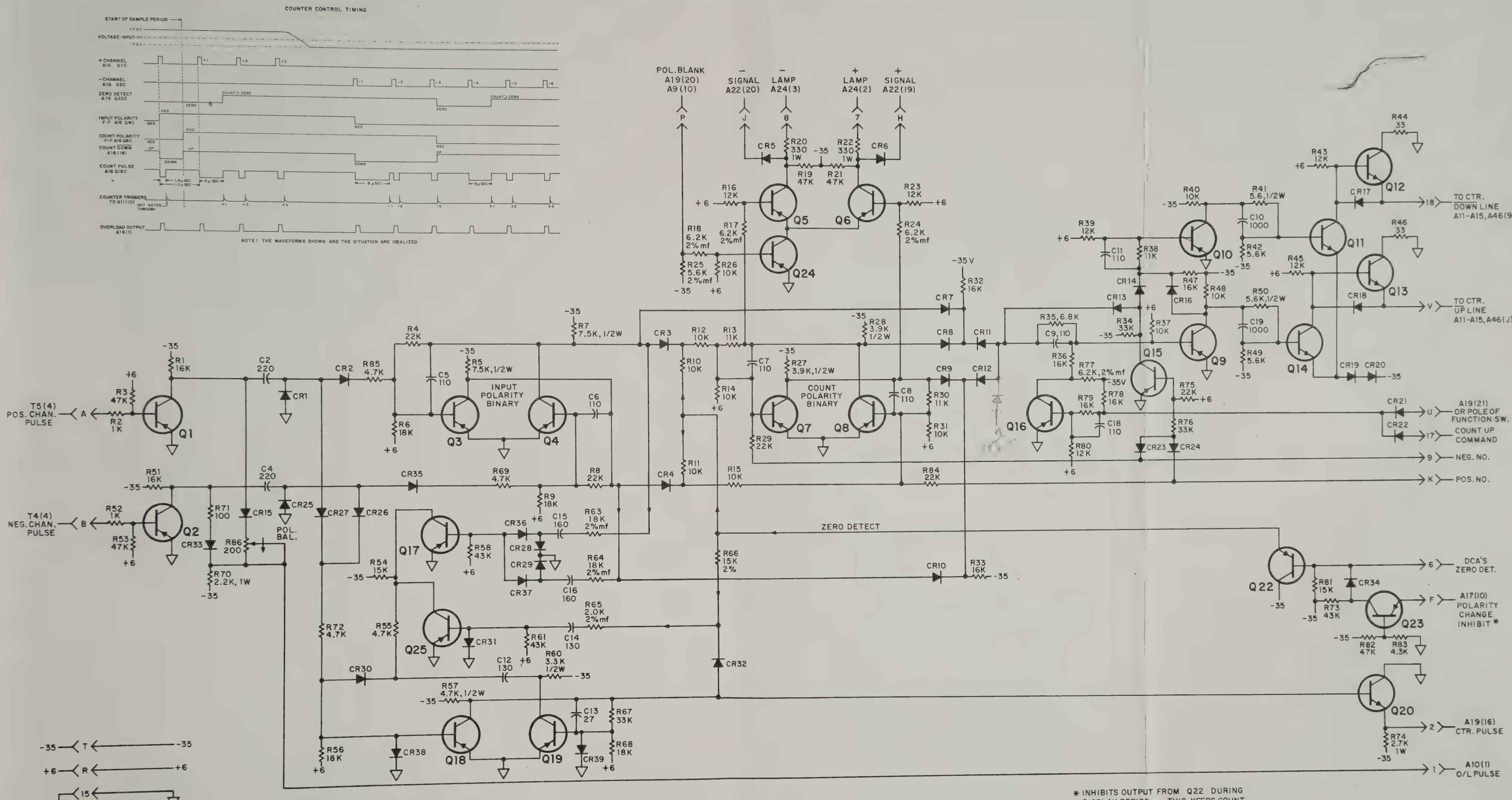




COUNTER CONTROL ASSEMBLY (A16)

5060-3809

FIGURE 4.25



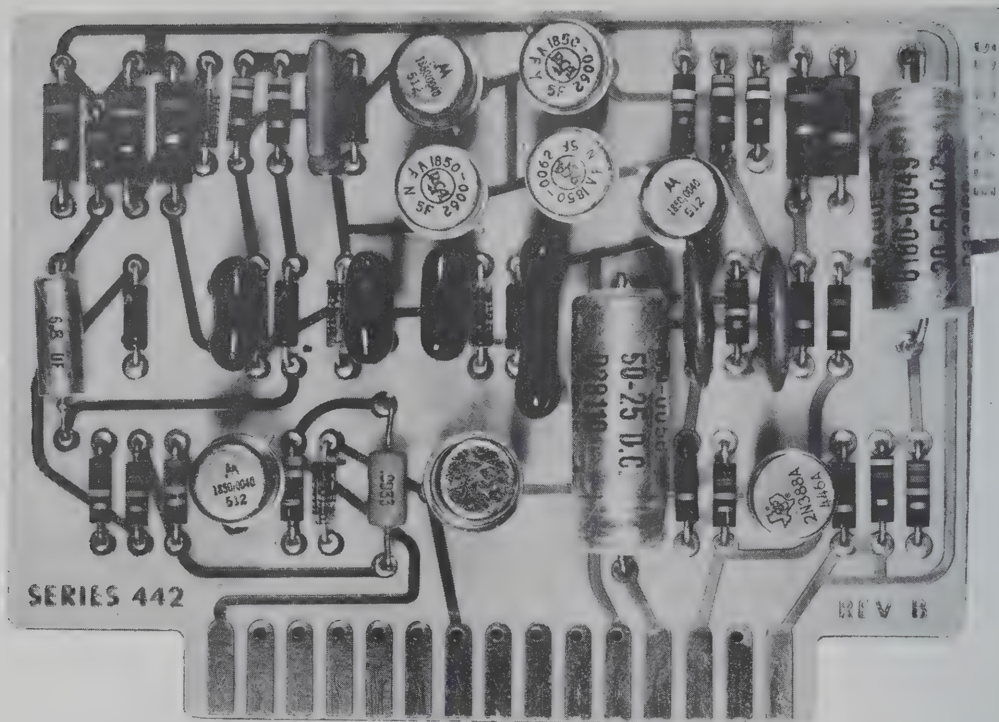
* INHIBITS OUTPUT FROM Q22 DURING DISPLAY PERIOD. THIS KEEPS COUNT POLARITY FROM CHANGING STATE, CHANGING THE DISPLAYED POLARITY

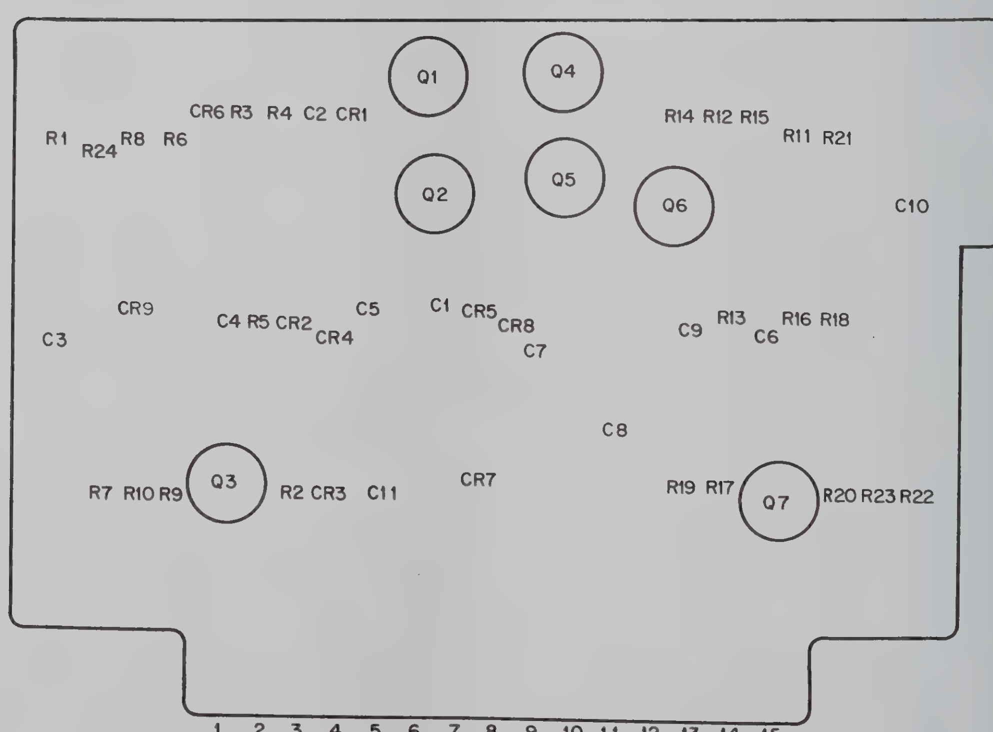
UNLESS OTHERWISE SPECIFIED
ALL RESISTANCE IN OHMS
ALL RESISTORS 1/4W, 5%
ALL CAPACITANCE IN PICO-FARADS

D5060-3809

COUNTER CONTROL CIRCUIT (A16)

FIGURE 4.26



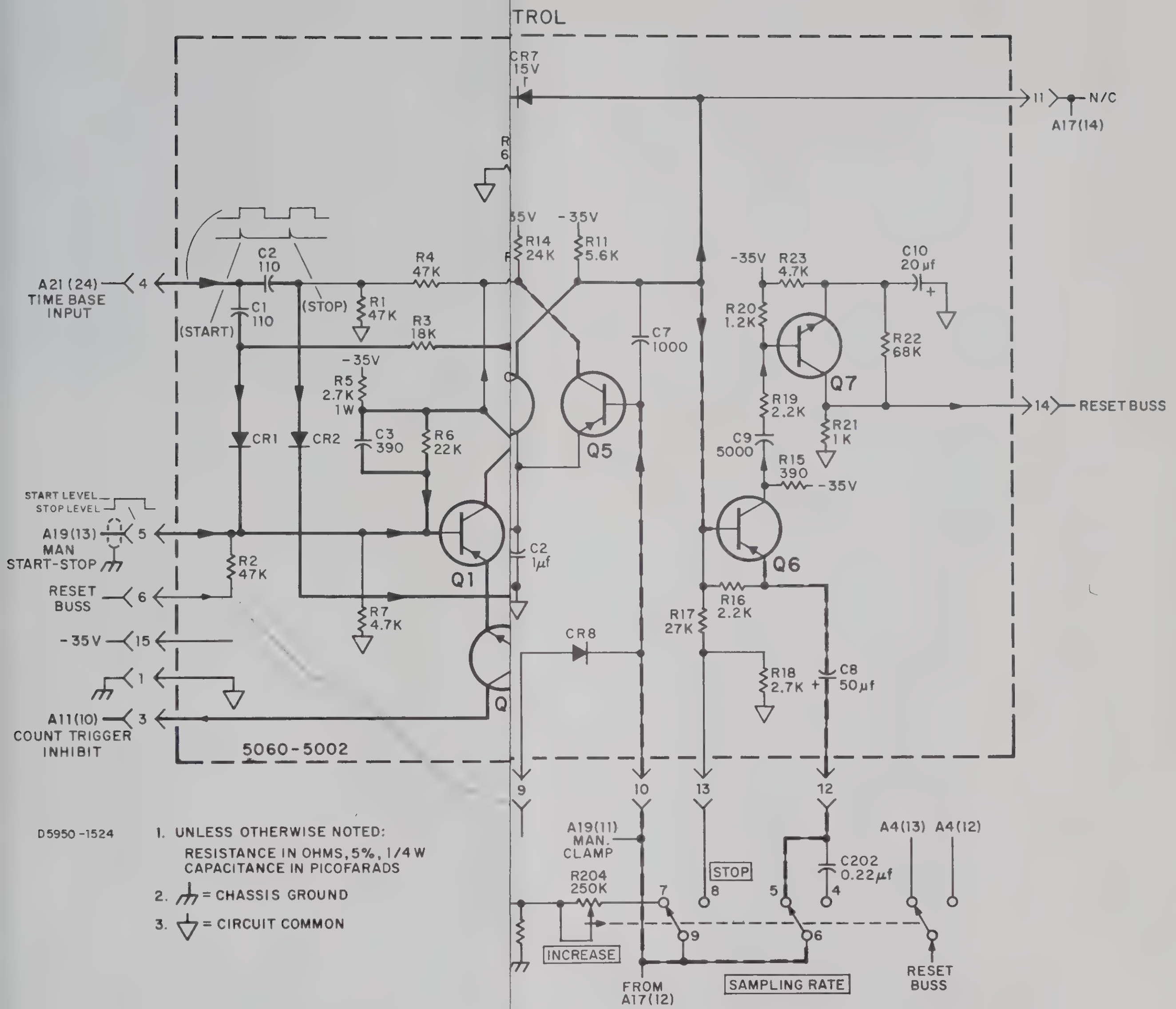


DISPLAY CONTROL ASSEMBLY (A18)

5060-2052

ASSEMBLIES A17 & A18

FIGURE 4.27

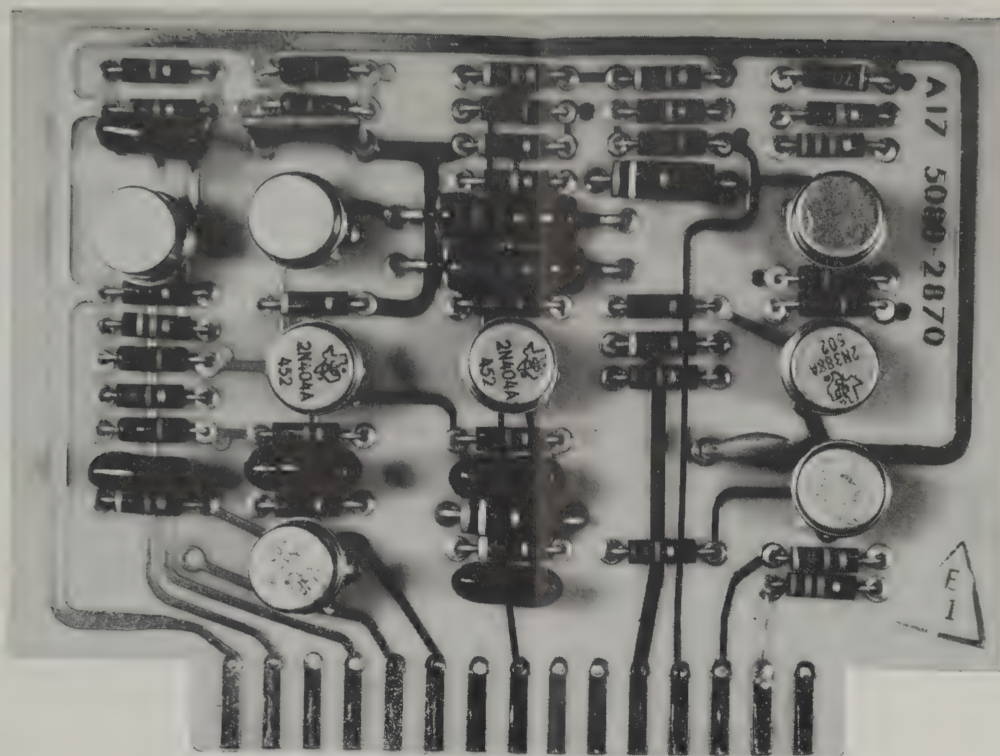


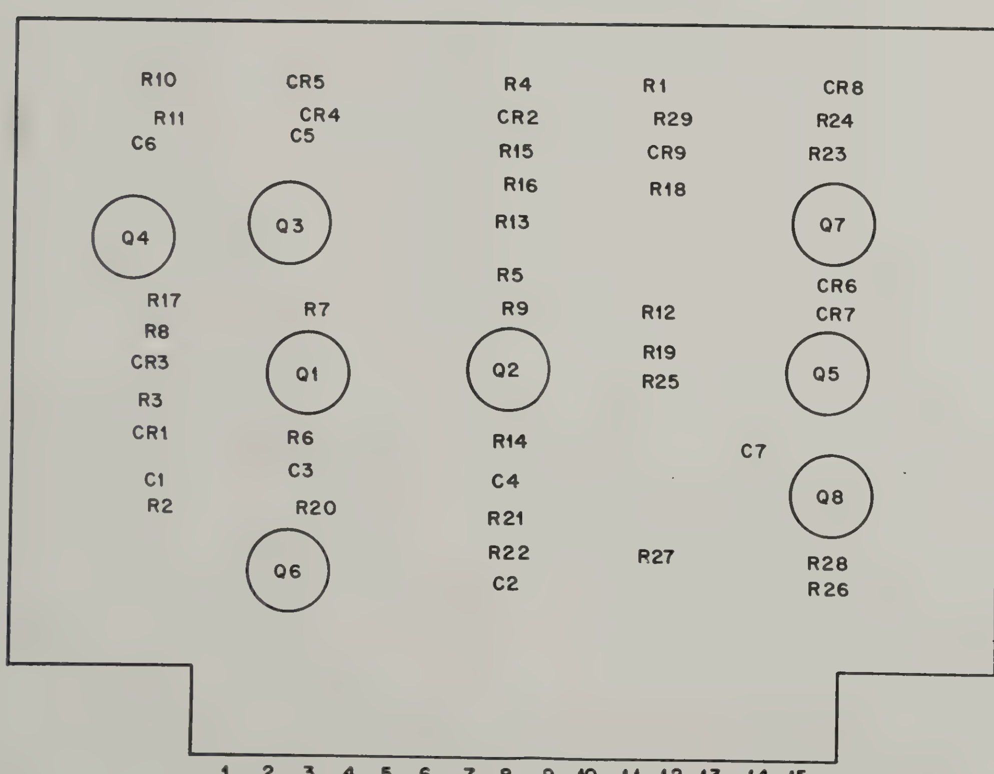
D5950-1524

1. UNLESS OTHERWISE NOTED:
   RESISTANCE IN OHMS, 5%, 1/4 W
   CAPACITANCE IN PICOFARADS
2. = CHASSIS GROUND
3. = CIRCUIT COMMON

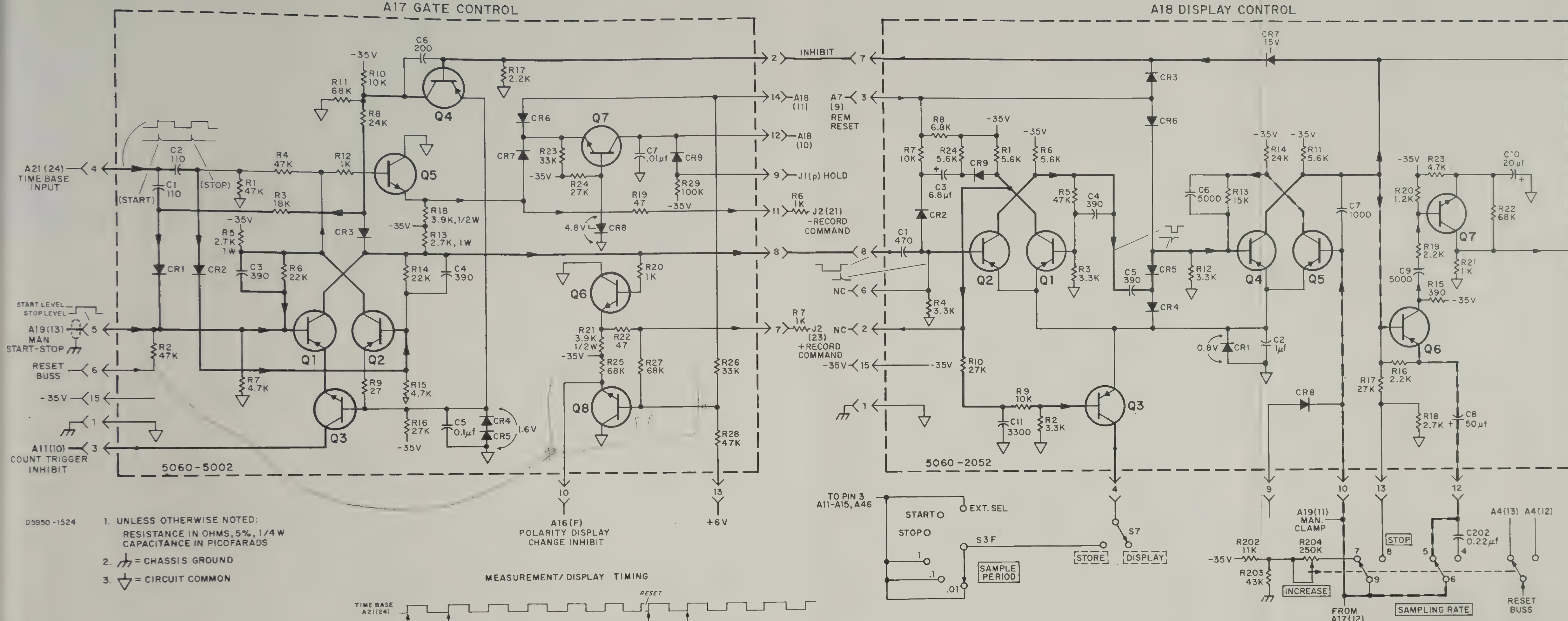
GATE AND DISPLAY CONTROL CIRCUITS (A17 & A18)

FIGURE 4.28





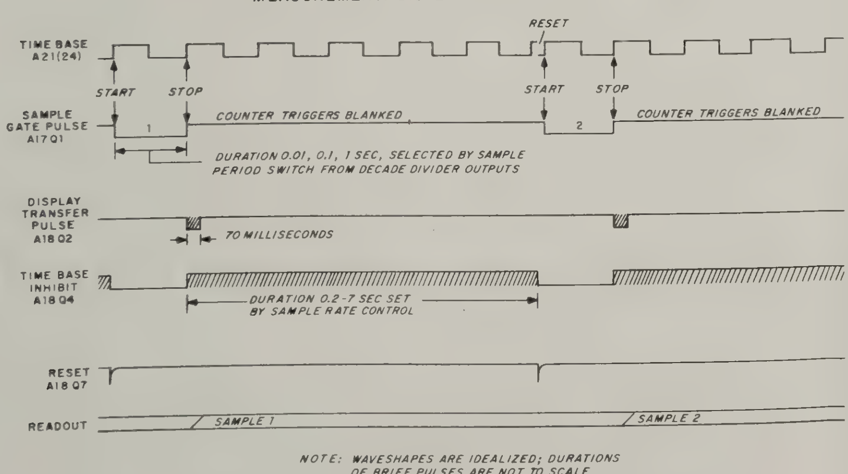
GATE CONTROL ASSEMBLY (A17)
5060-5002



D5950-1524

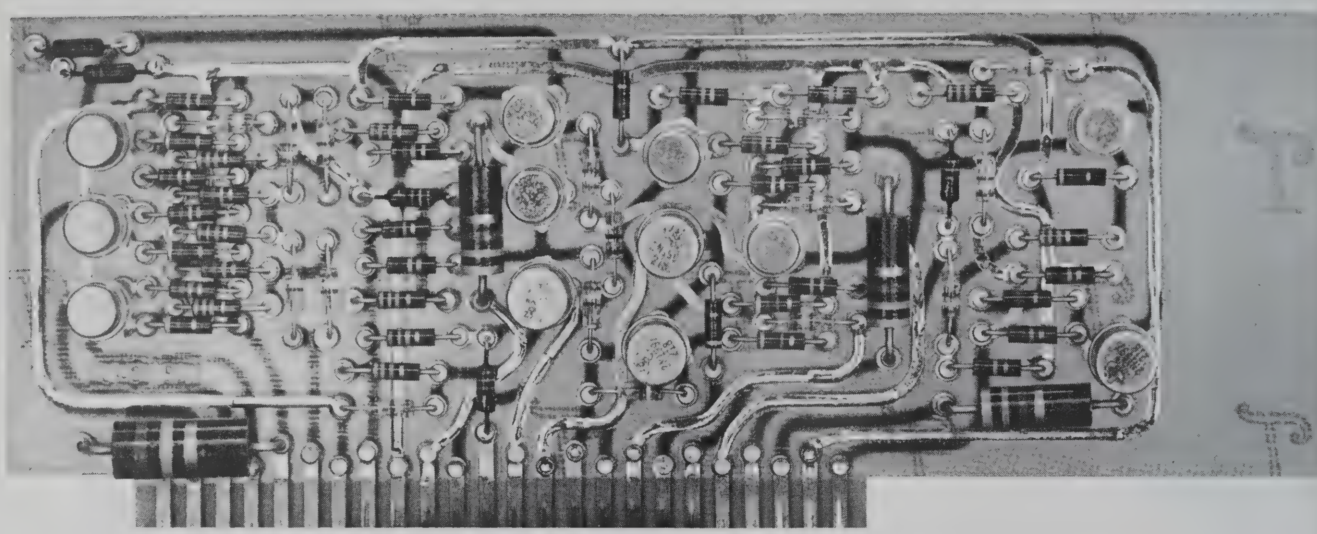
1. UNLESS OTHERWISE NOTED: RESISTANCE IN OHMS, 5%, 1/4 W CAPACITANCE IN PICOFARADS
2. = CHASSIS GROUND
3. = CIRCUIT COMMON

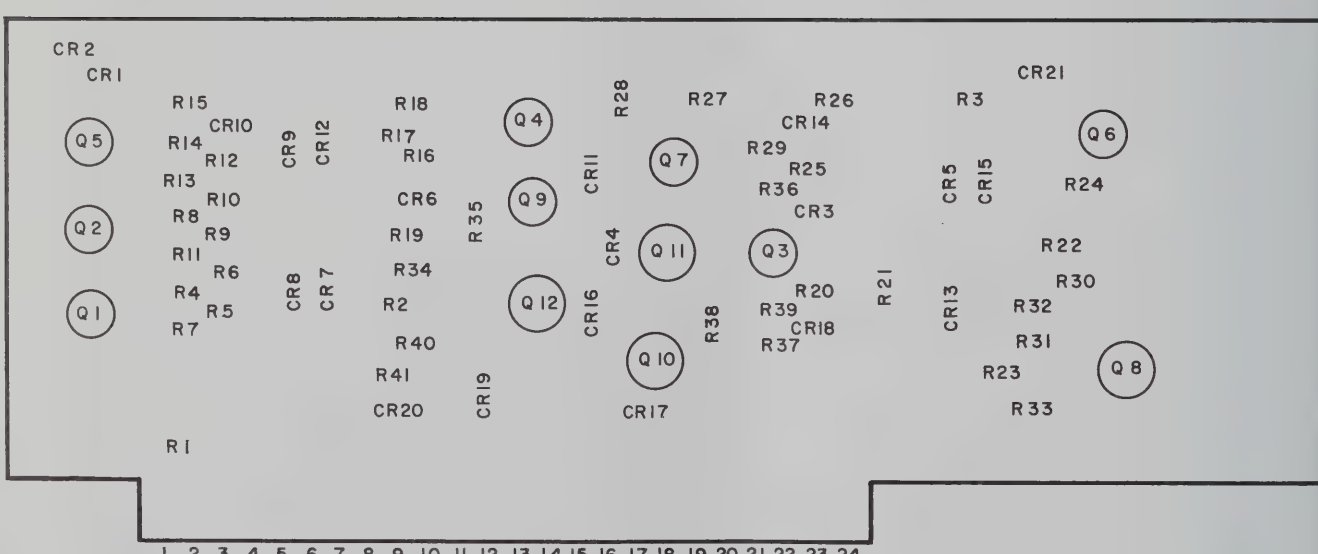
MEASUREMENT/ DISPLAY TIMING



GATE AND DISPLAY CONTROL CIRCUITS (A17 & A18)

FIGURE 4.28

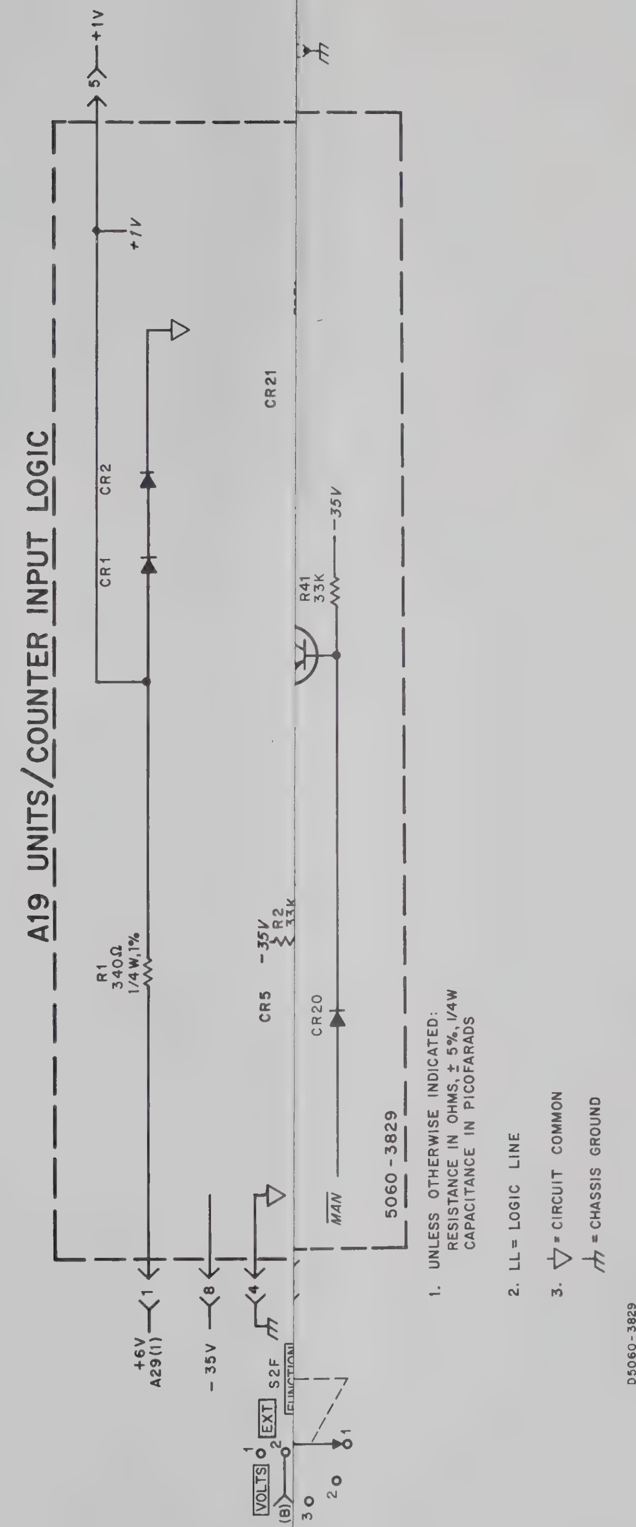




UNITS/COUNTER INPUT LOGIC ASSEMBLY (A19)

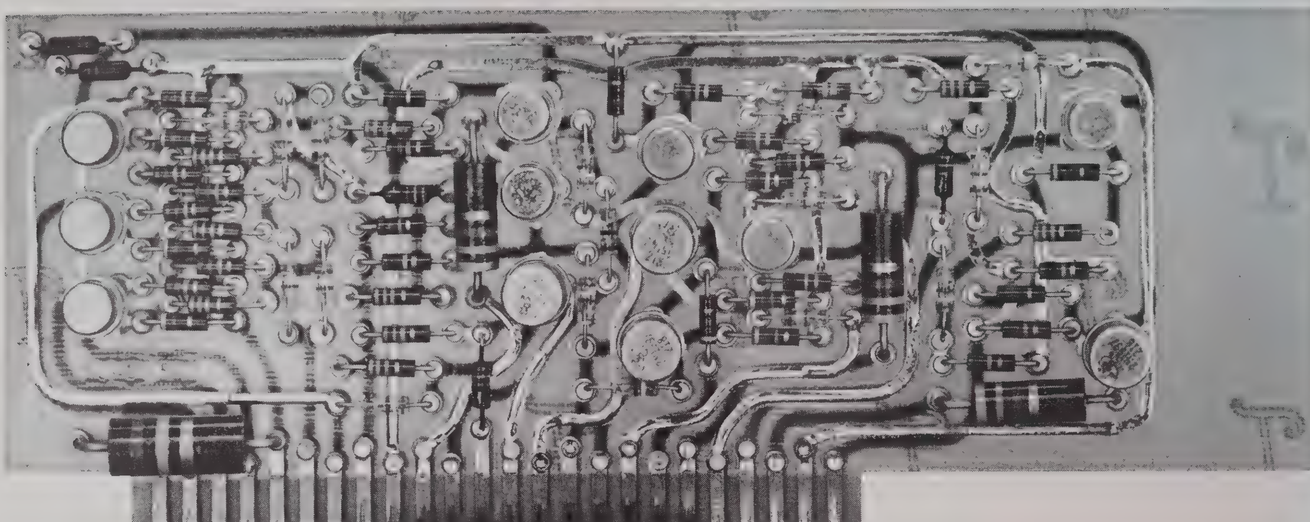
5060-3829

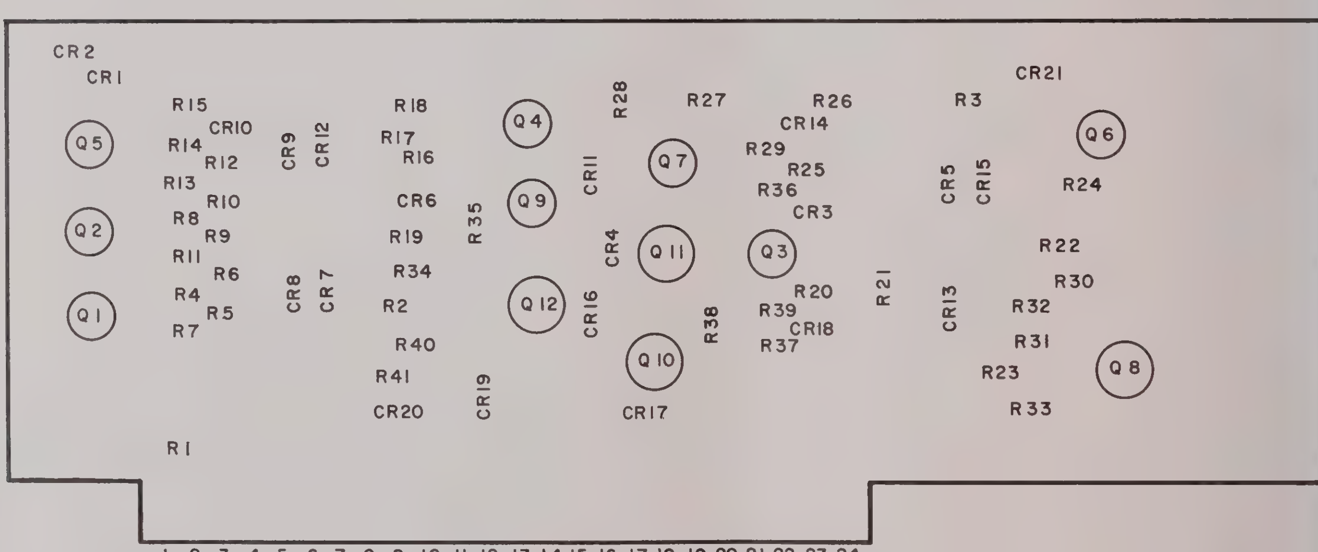
FIGURE 4.29



UNITS/COUNTER INPUT LOGIC CIRCUIT (A19)

FIGURE 4.30

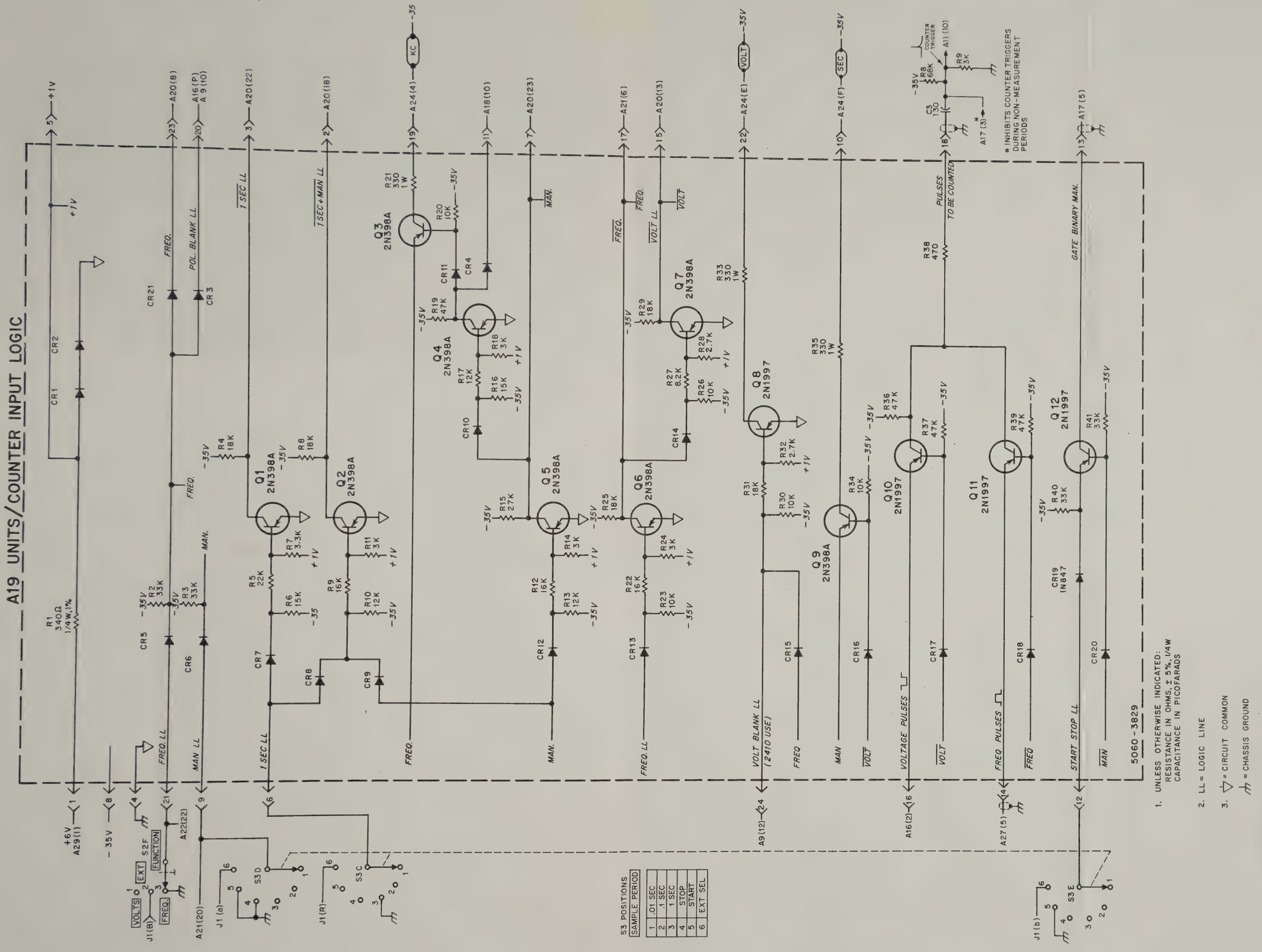




UNITS/COUNTER INPUT LOGIC ASSEMBLY (A19)

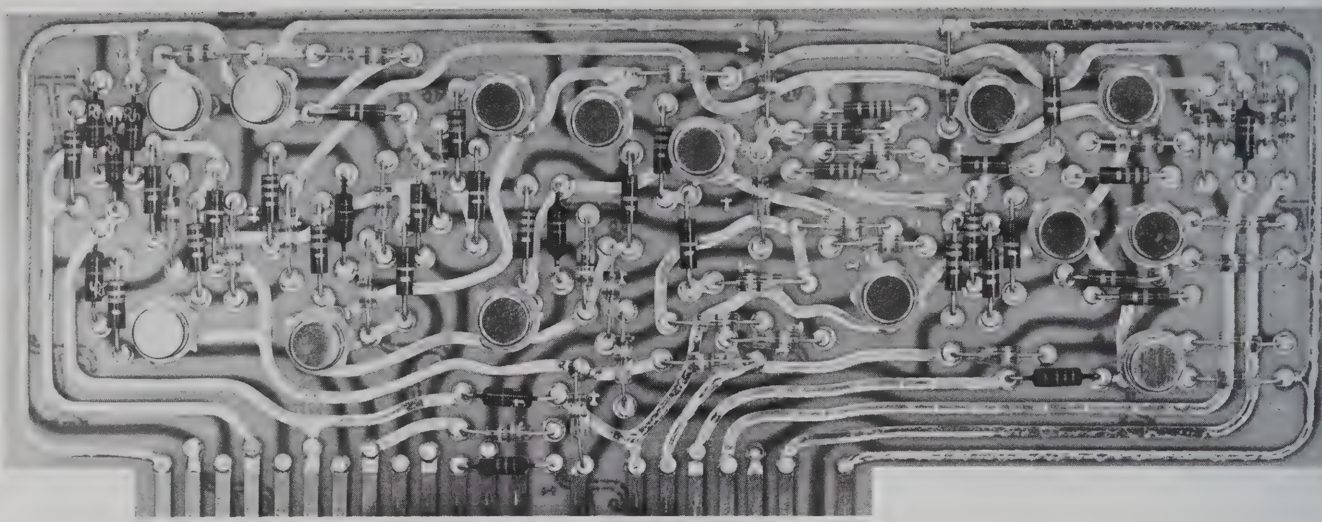
5060-3829

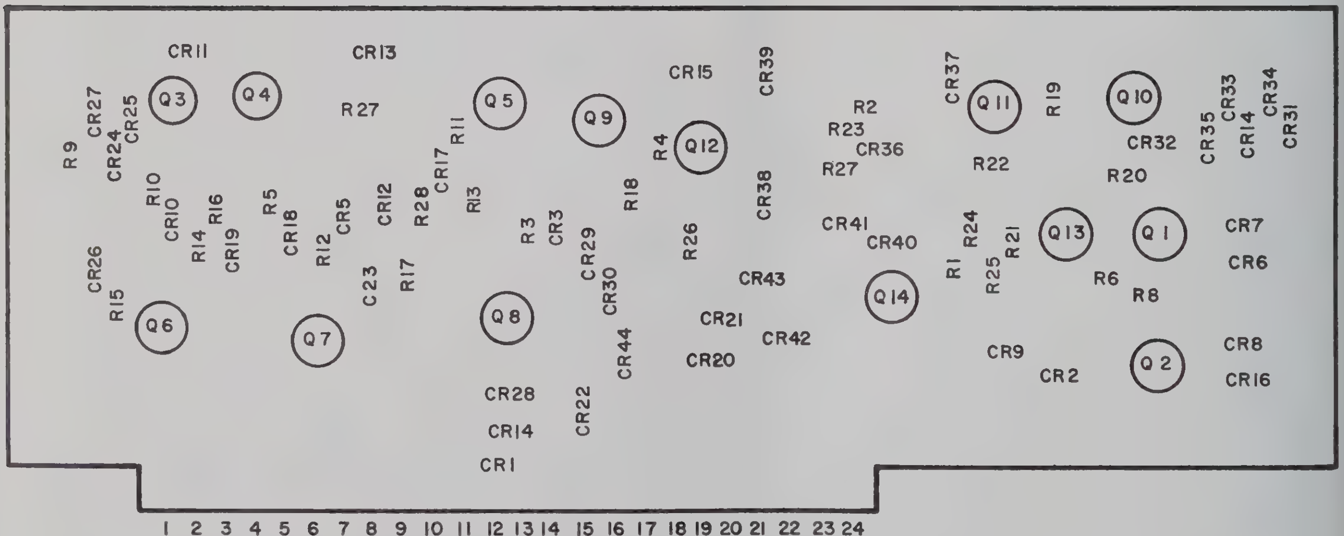
FIGURE 4.29



UNITS/COUNTER INPUT LOGIC CIRCUIT (A19)

FIGURE 4.30

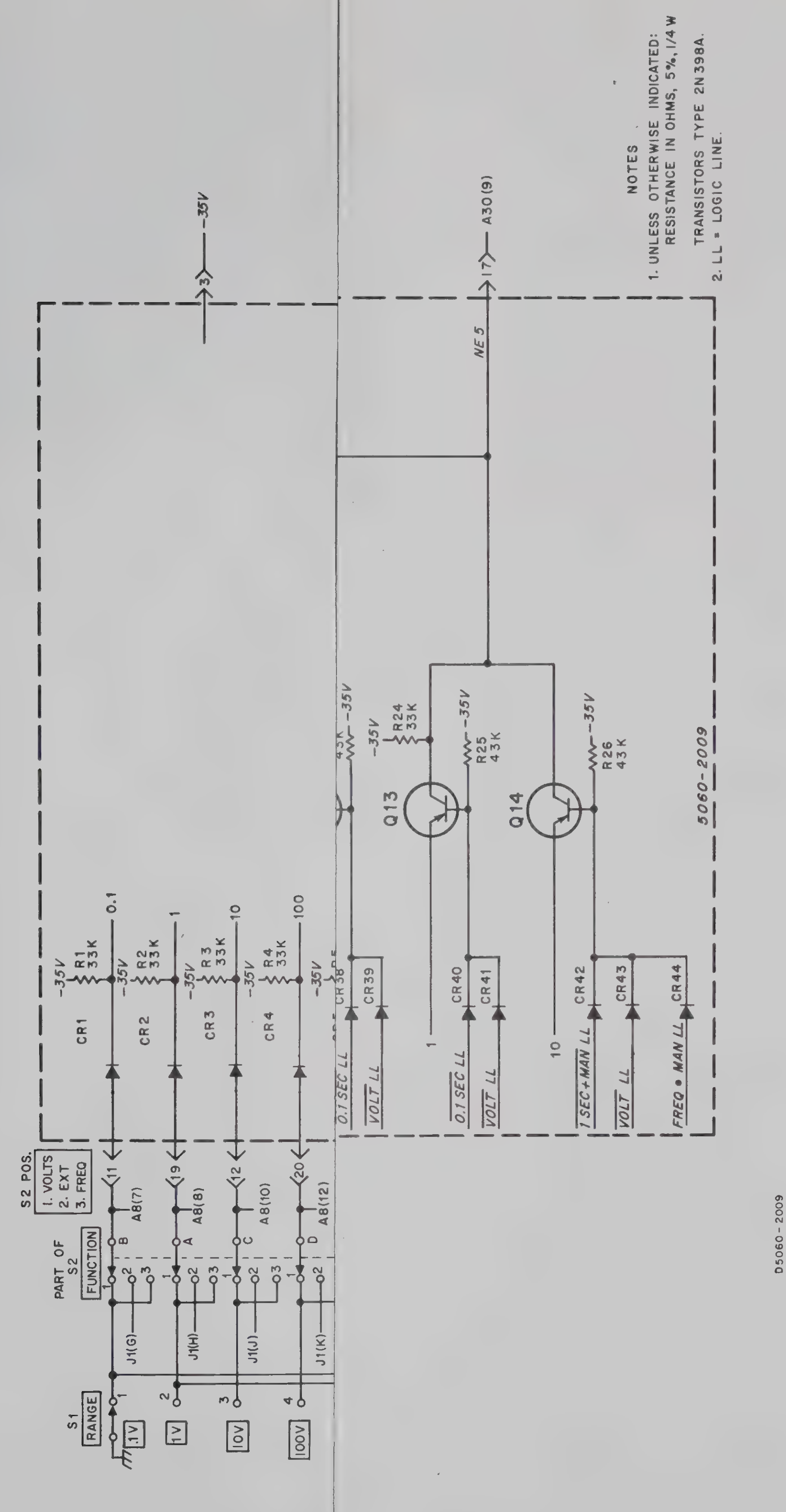




DECIMAL POINT LOGIC ASSEMBLY (A20)

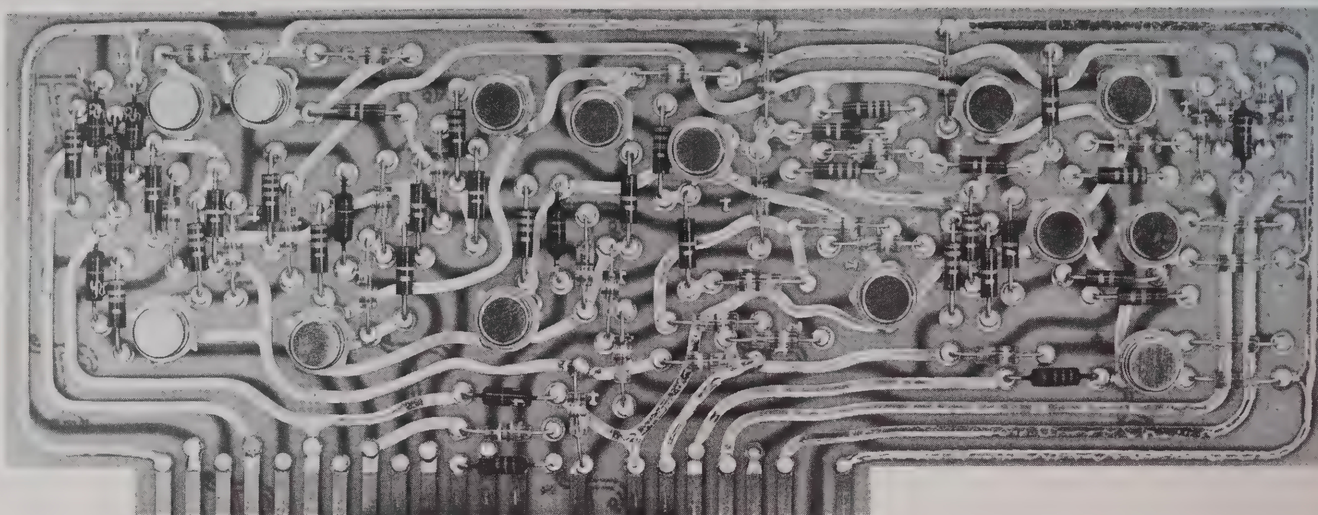
5060-2009

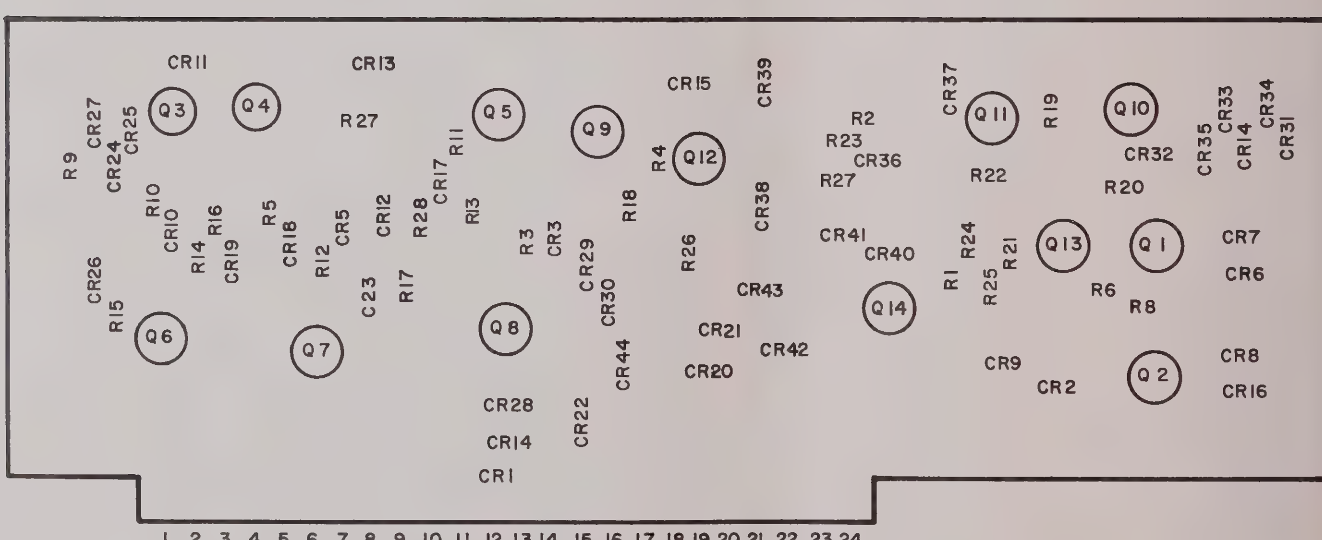
FIGURE 4.31



DECIMAL POINT LOGIC CIRCUIT (A20)

FIGURE 4.32

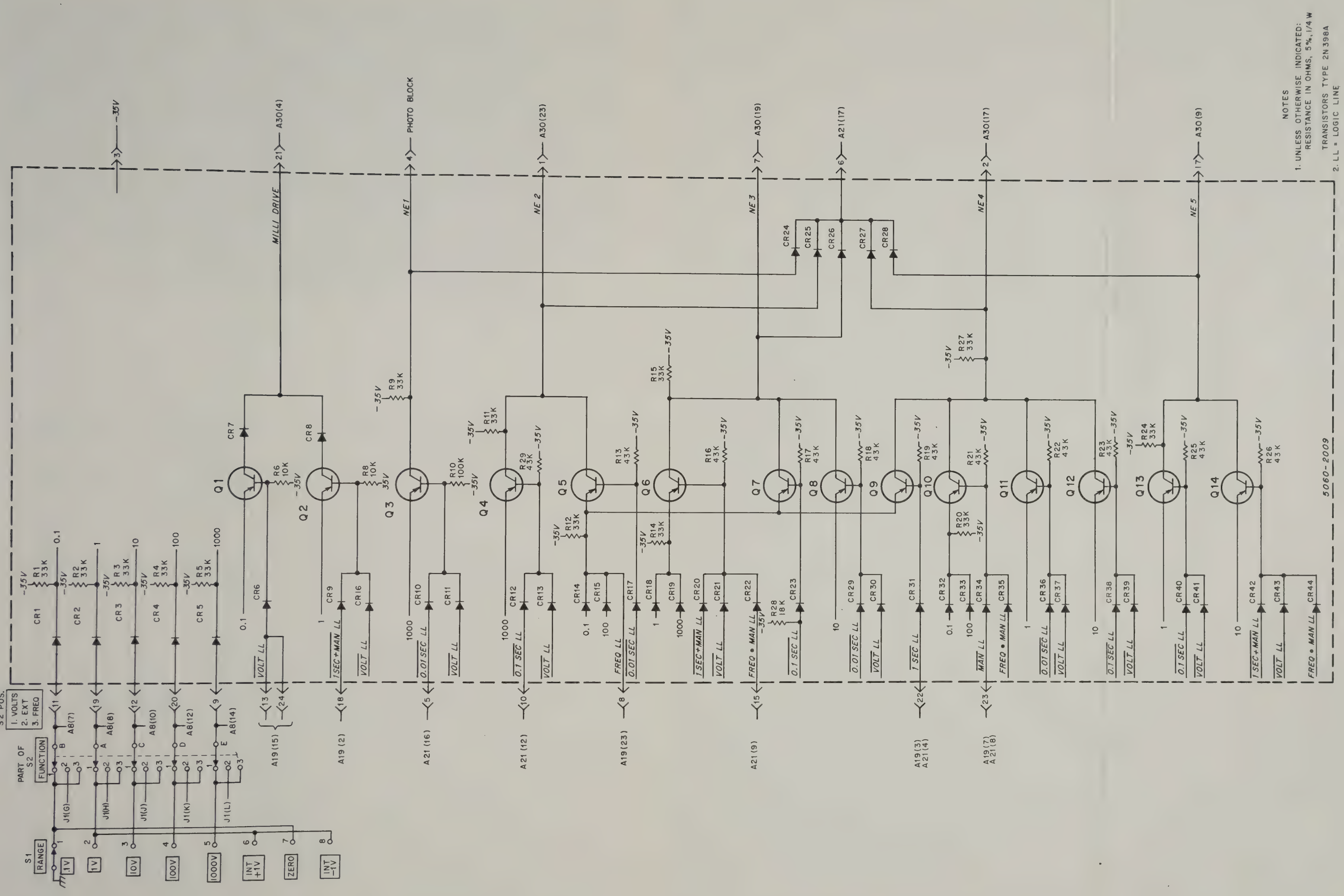




DECIMAL POINT LOGIC ASSEMBLY (A20)

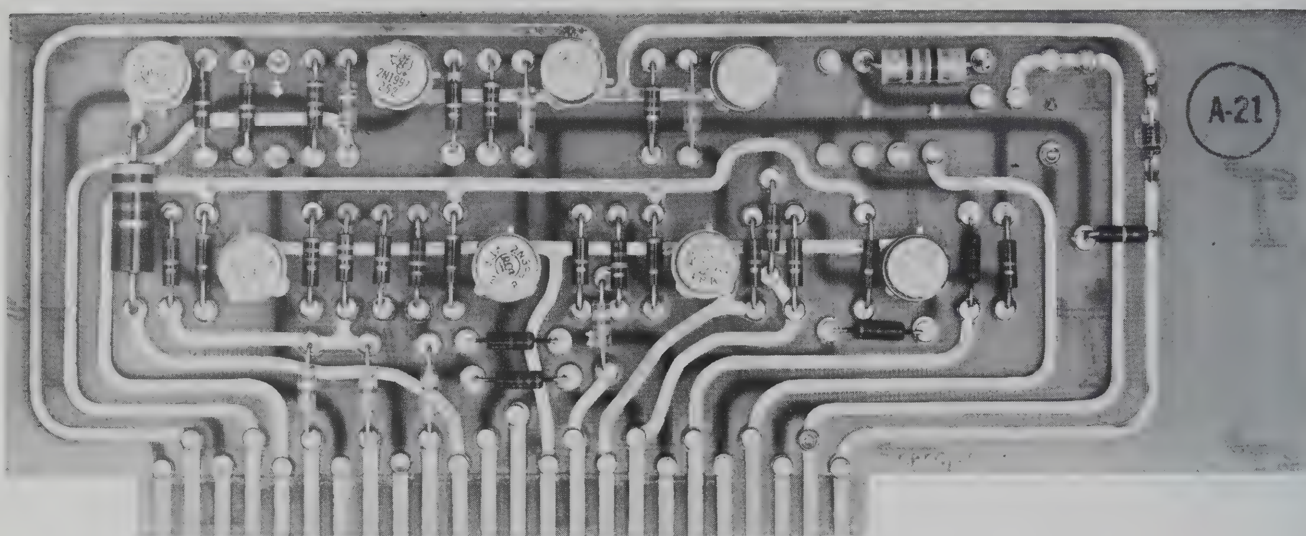
5060-2009

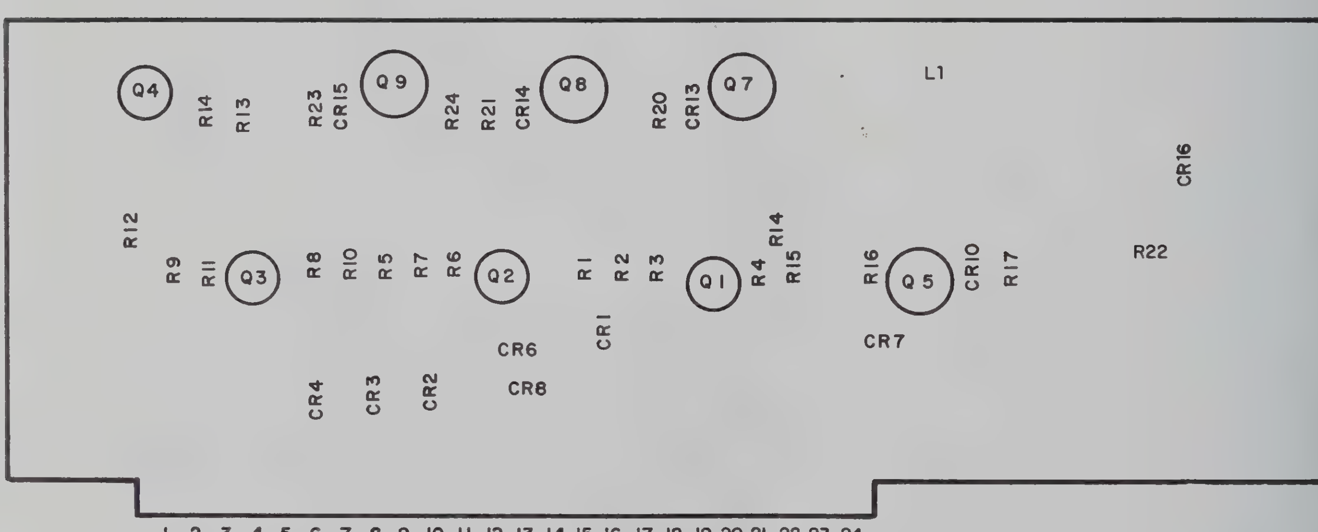
FIGURE 4.31



DECIMAL POINT LOGIC CIRCUIT (A20)

FIGURE 4.32

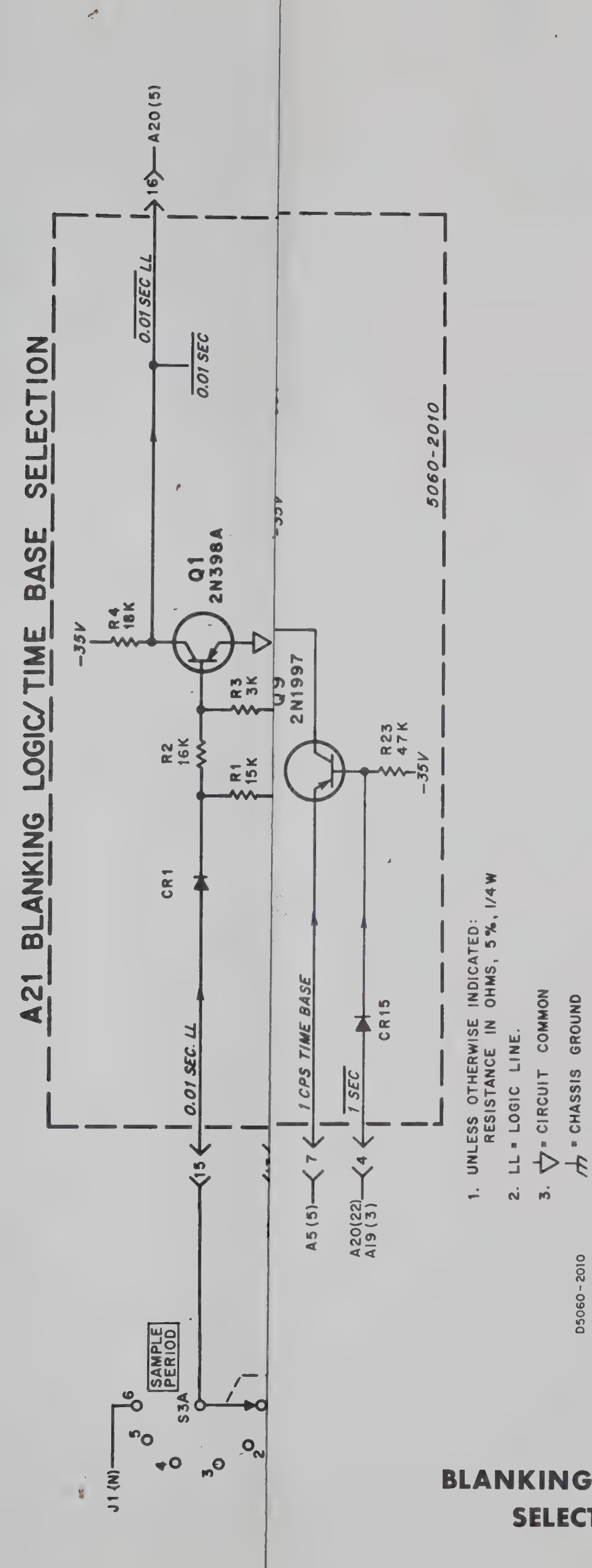




BLANKING LOGIC /TIME BASE SELECTION ASSEMBLY (A21)

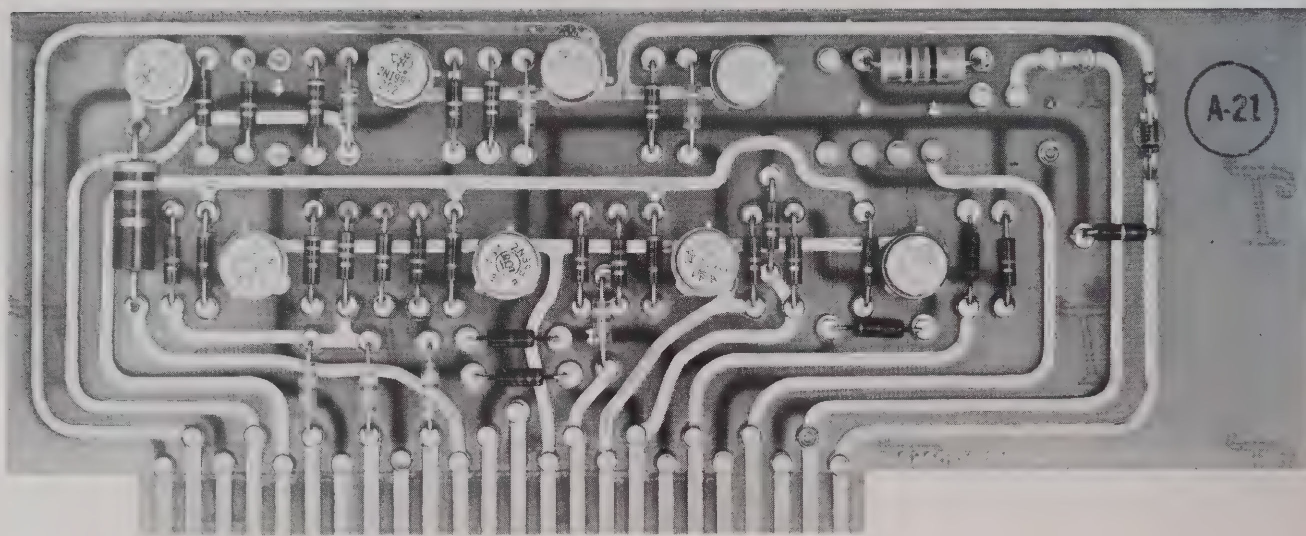
5060-2010

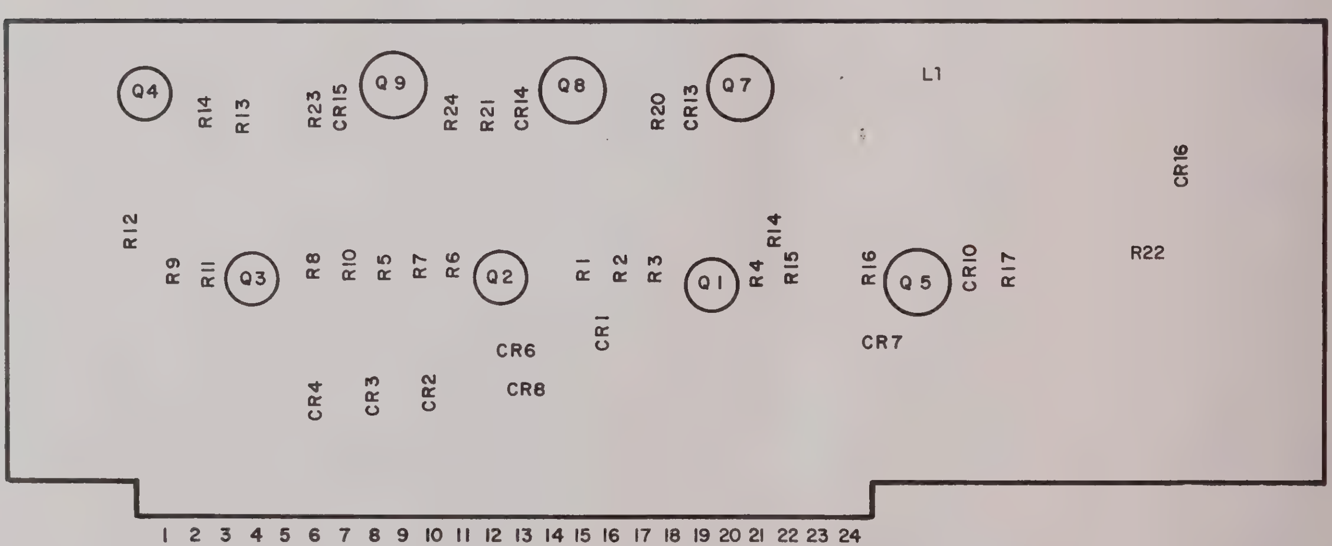
FIGURE 4.33



BLANKING LOGIC/TIME BASE SELECTION CIRCUIT (A21)

FIGURE 4.34

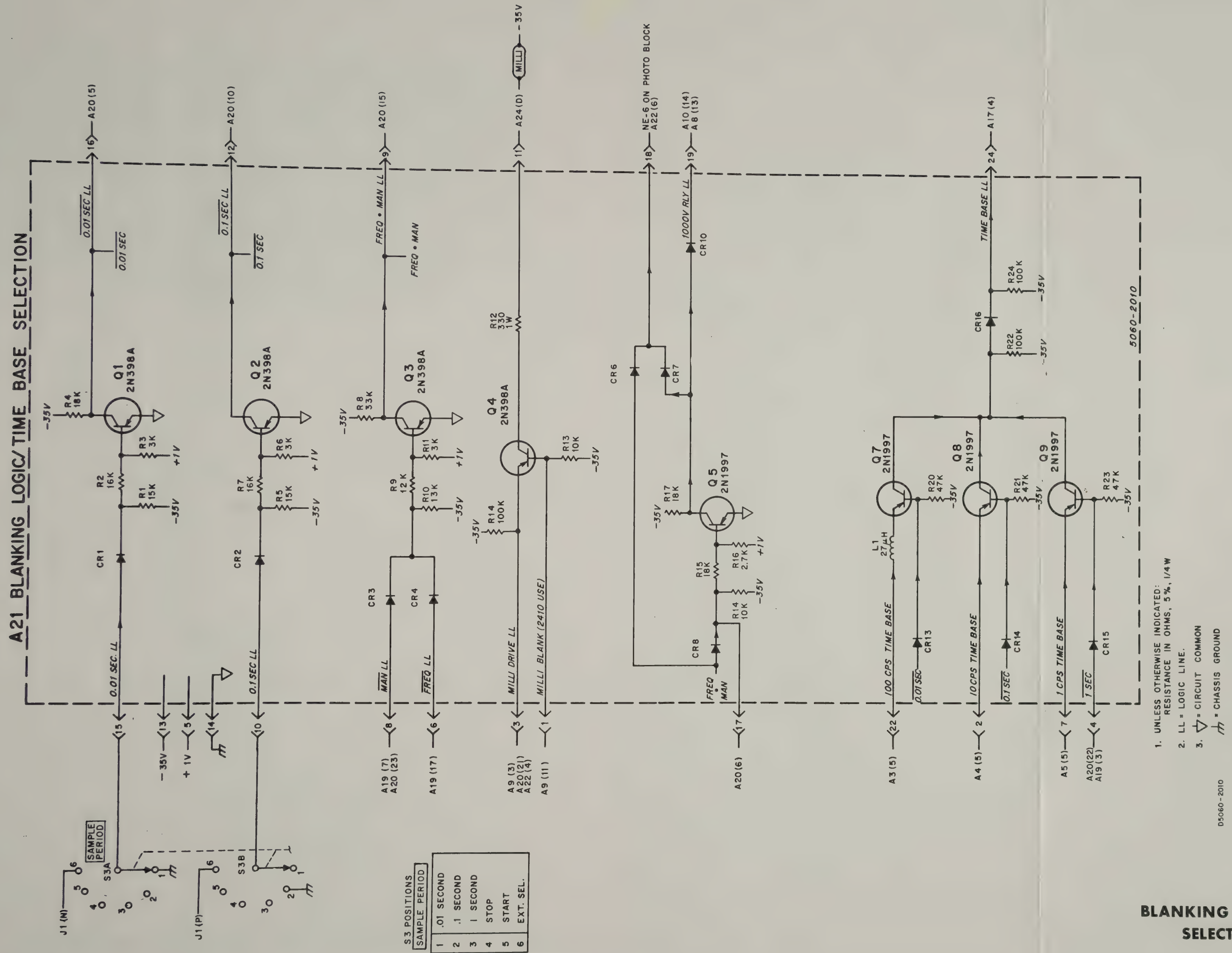




BLANKING LOGIC /TIME BASE SELECTION ASSEMBLY (A21)

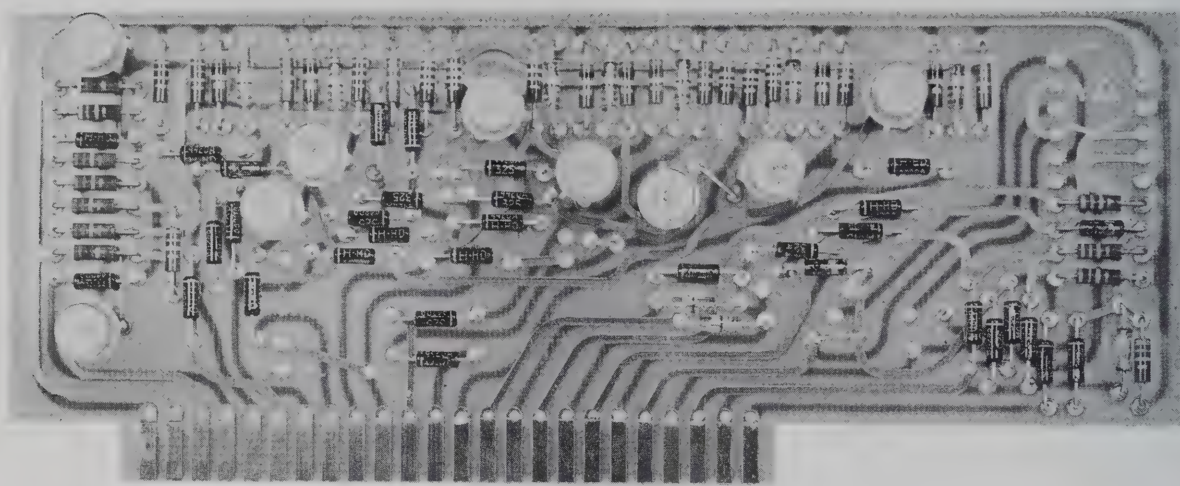
5060-2010

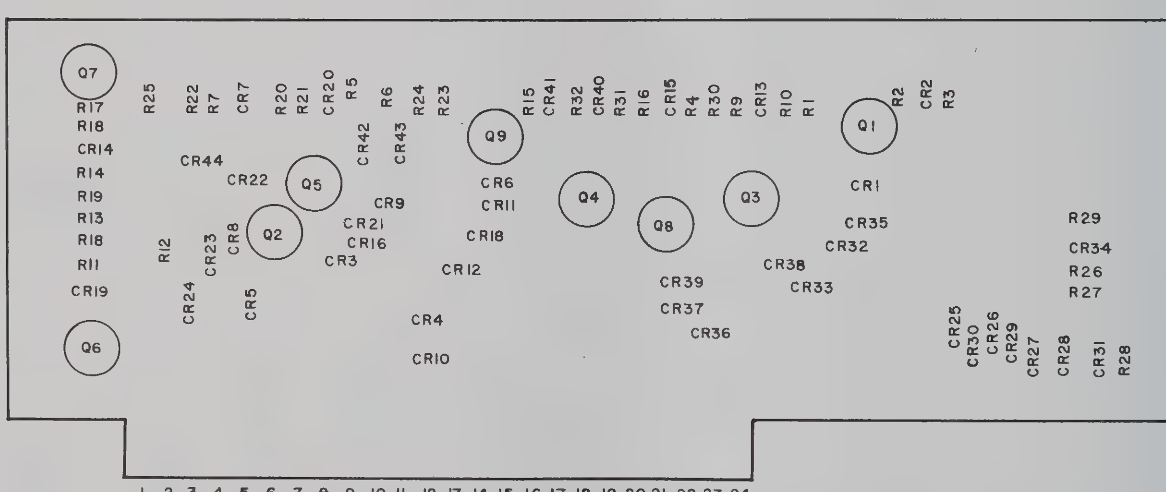
FIGURE 4.33



BLANKING LOGIC/TIME BASE SELECTION CIRCUIT (A21)

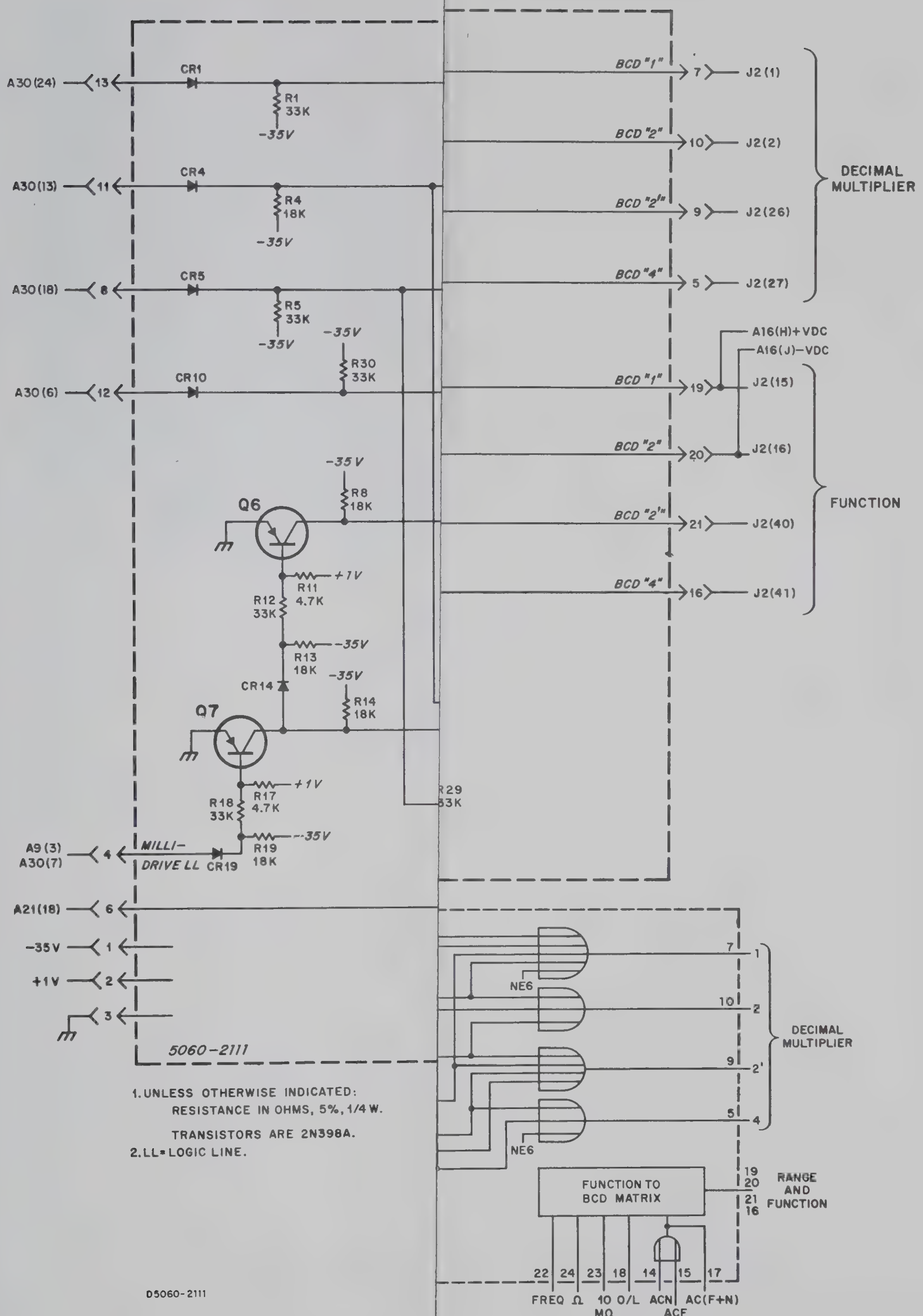
FIGURE 4.34





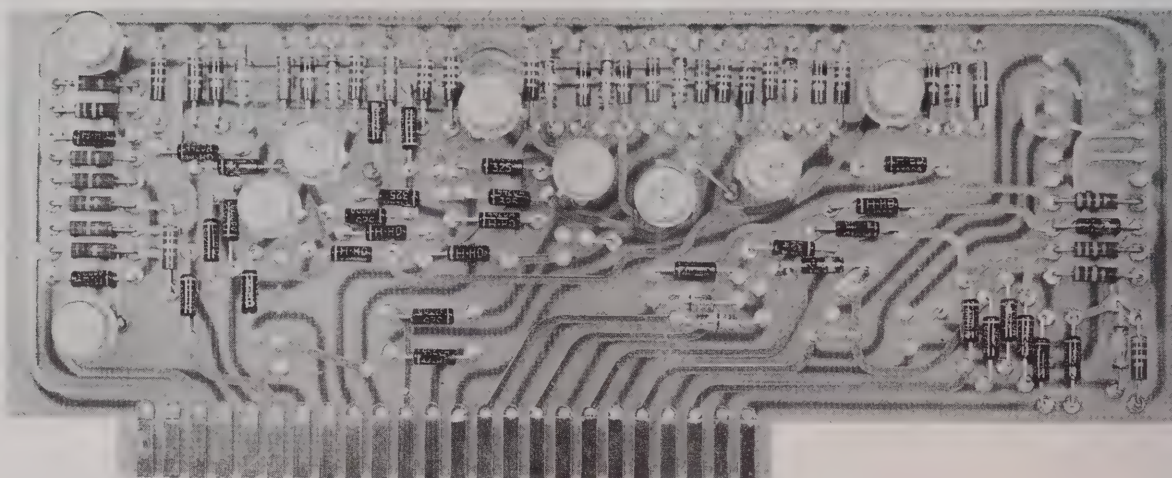
PRINTER COUPLING LOGIC ASSEMBLY (A22)
5060-2111

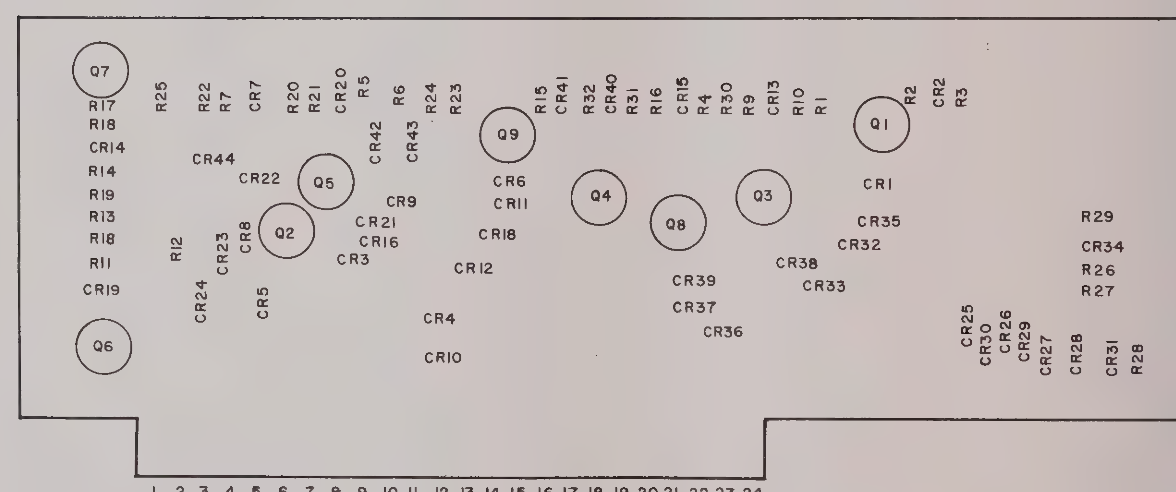
FIGURE 4.35



PRINTER COUPLING CIRCUIT (A22)

FIGURE 4.36

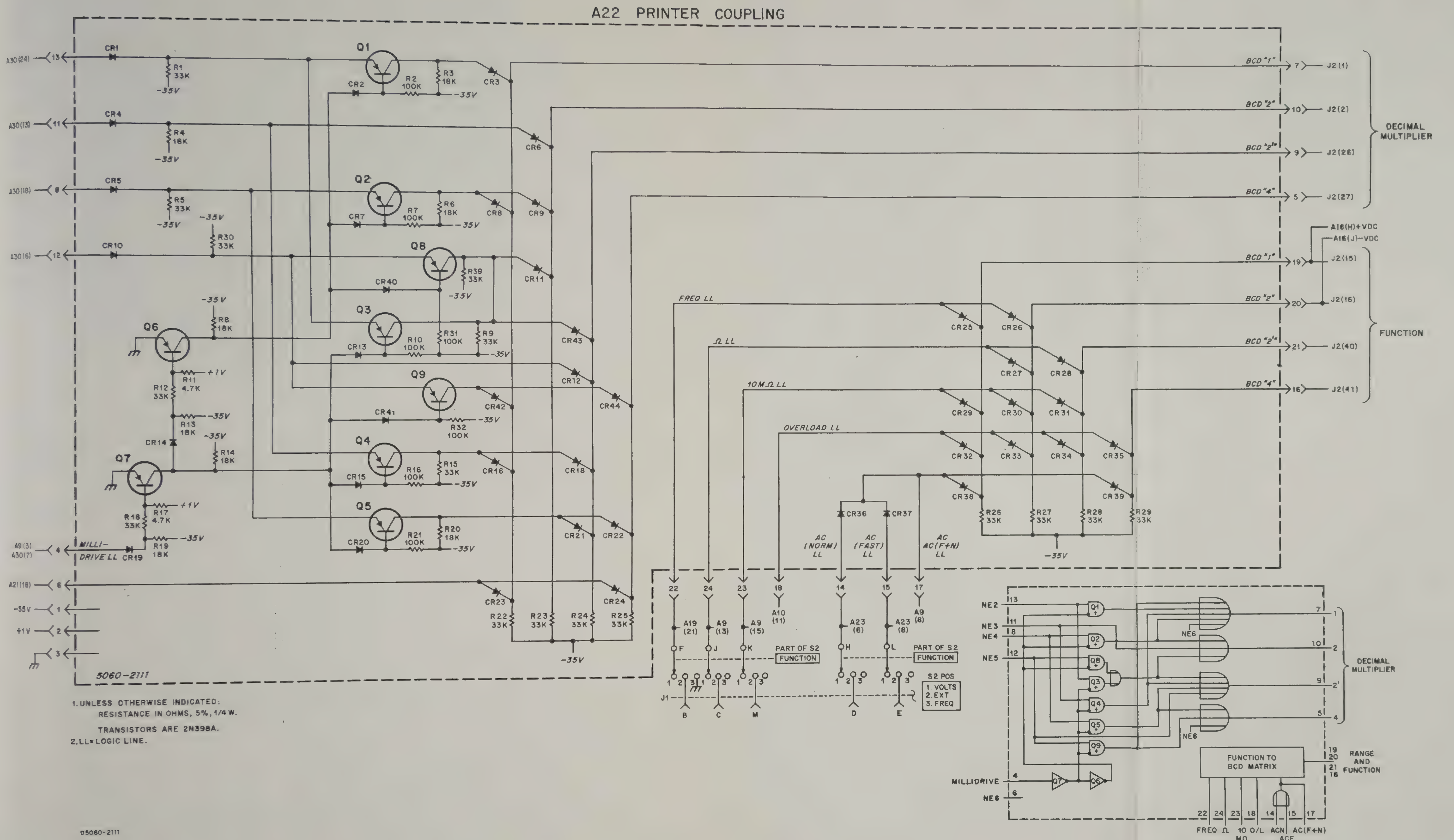




PRINTER COUPLING LOGIC ASSEMBLY (A22)

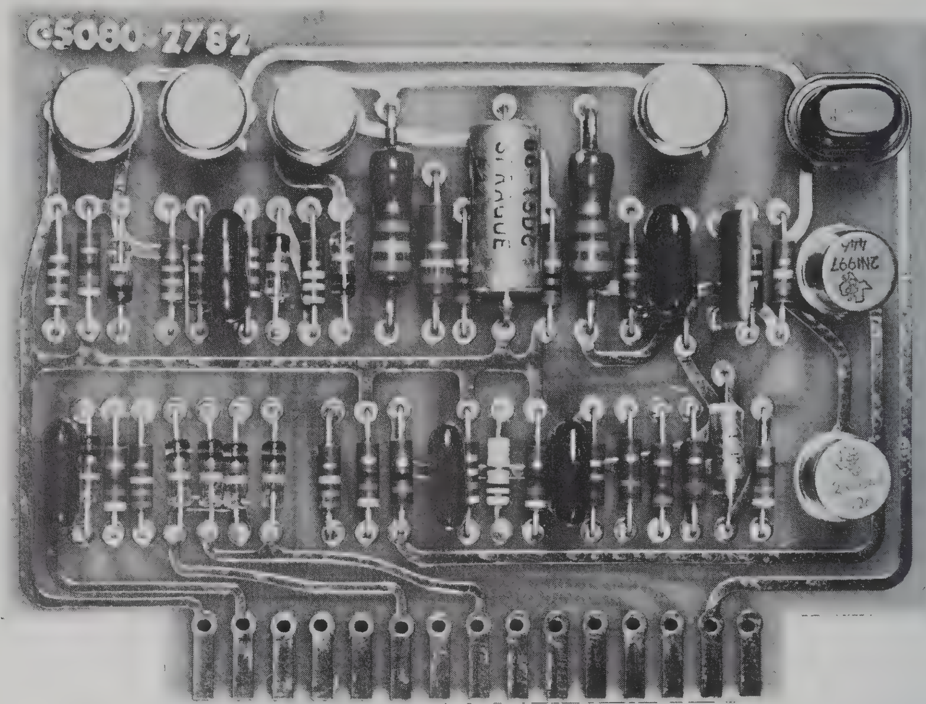
5060-2111

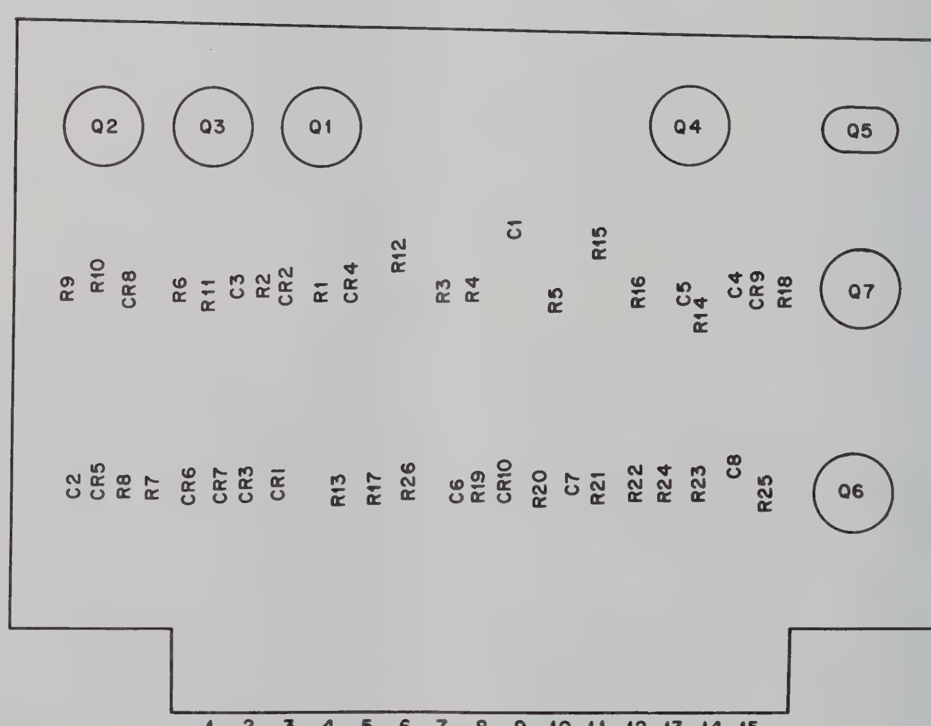
FIGURE 4.35



PRINTER COUPLING CIRCUIT (A22)

FIGURE 4.36

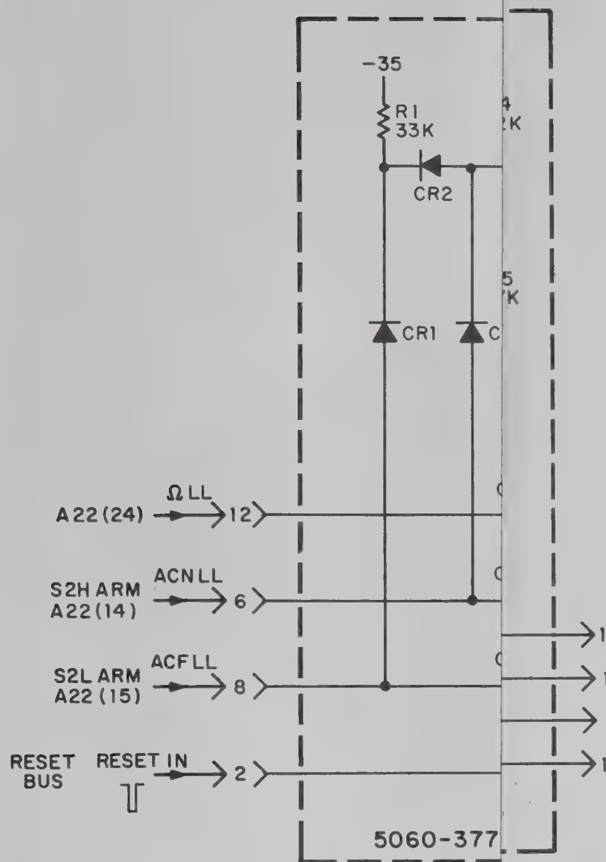


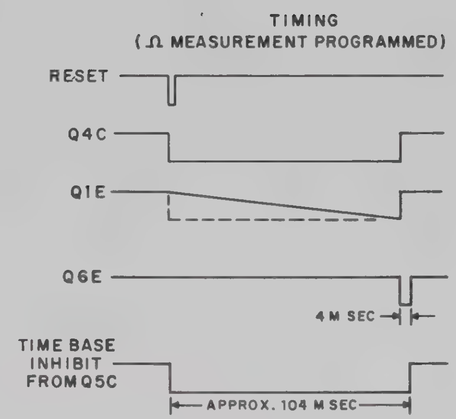


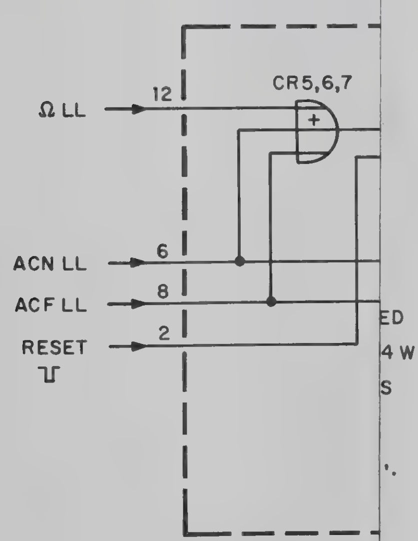
DY-2410B AC & OHMS DELAY GATE CARD (A23)

5060-3771

FIGURE 4.37



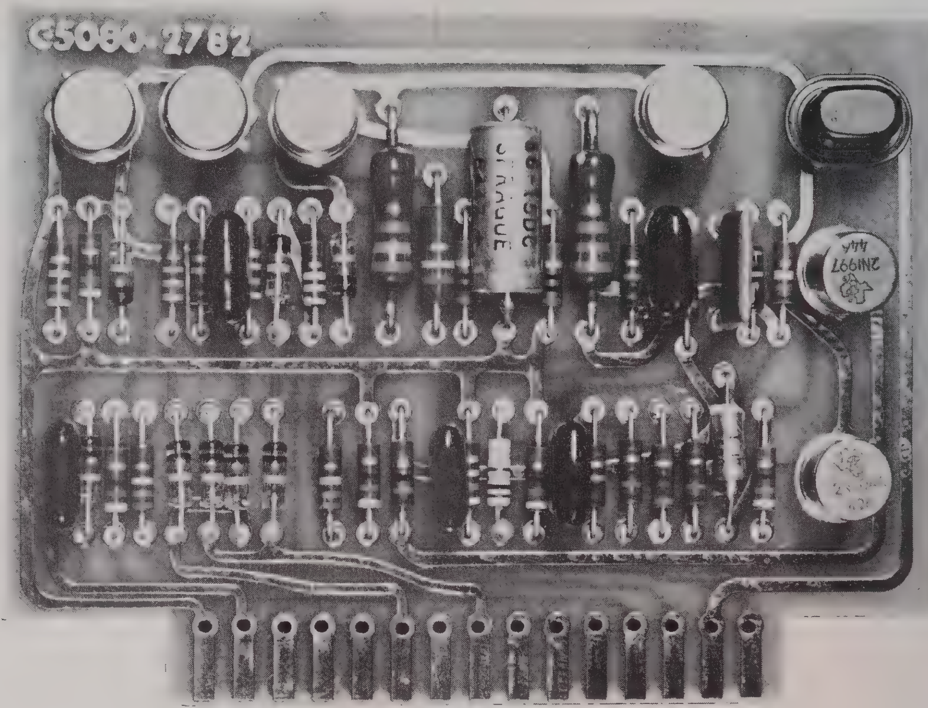


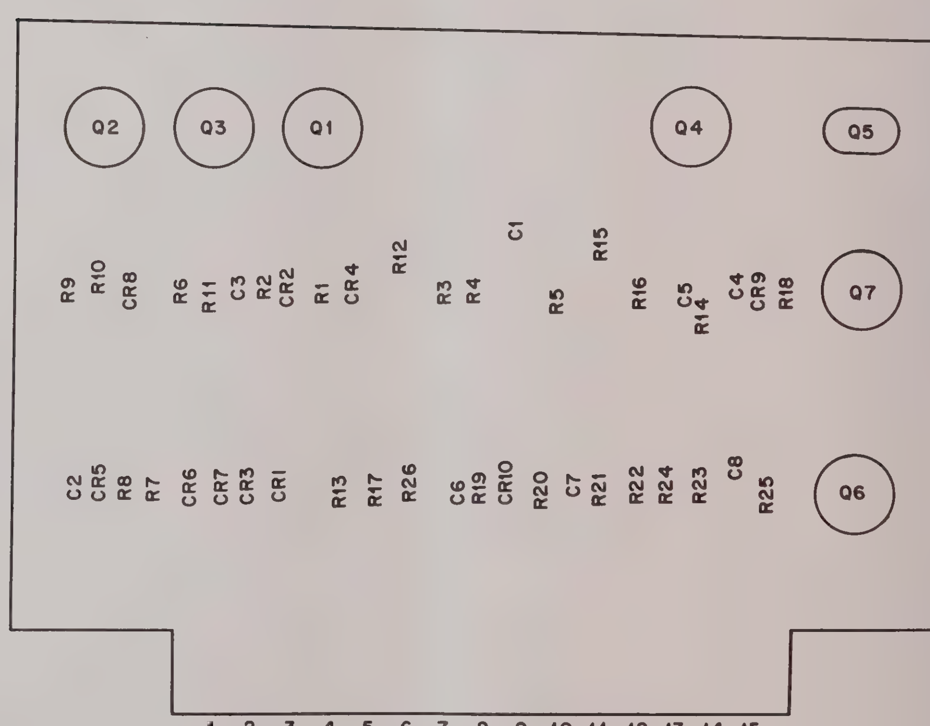


D5060-3771

DY-2410B AC & OHMS DELAY GATE CIRCUIT (A23)

FIGURE 4.38

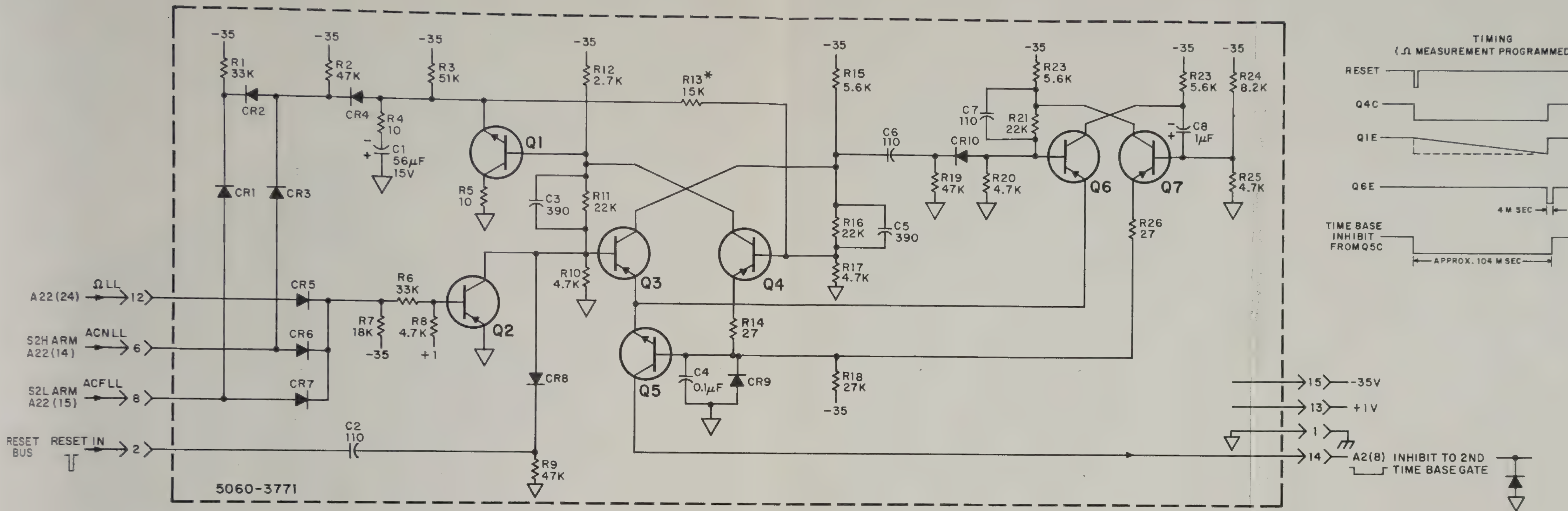


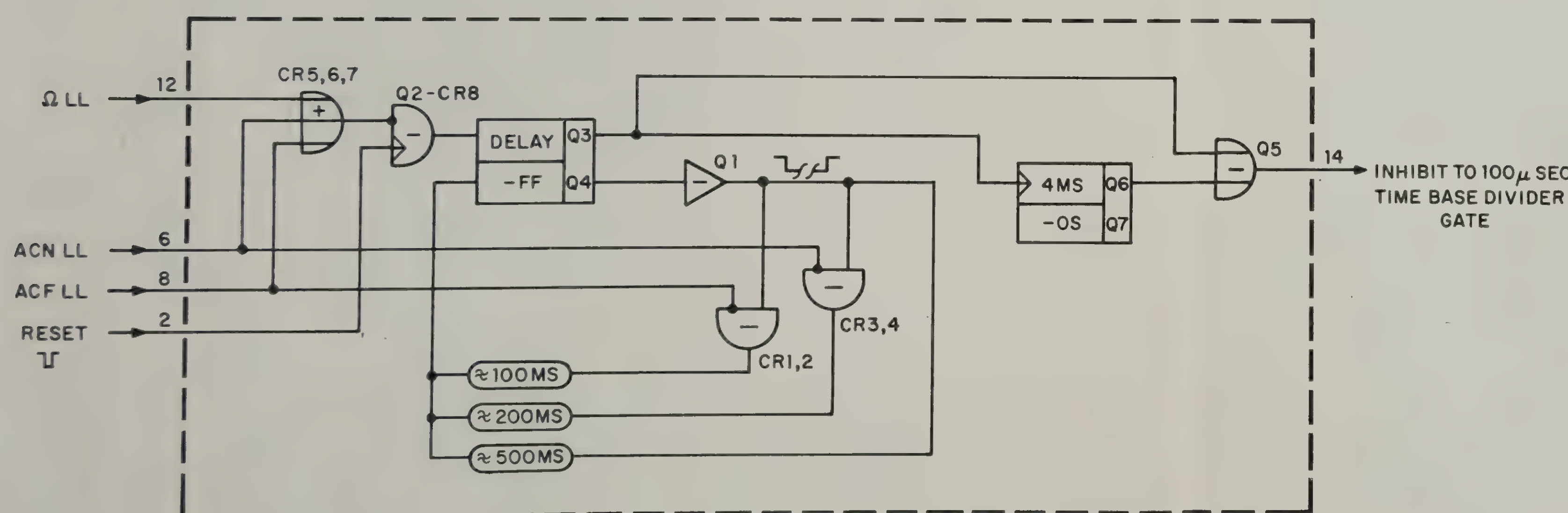


DY-2410B AC & OHMS DELAY GATE CARD (A23)

5060-3771

FIGURE 4.37





NOTES:

UNLESS OTHERWISE SPECIFIED

1. RESISTANCE IN OHMS, 5%, 1/4 W
2. CAPACITANCE IN PICOFARADS
3. DIODES TYPE IN292

* = FACTORY SELECTED VALUE, NOMINAL VALUE SHOWN

4. SHEET 2 ON C SIZE

D5060-3771

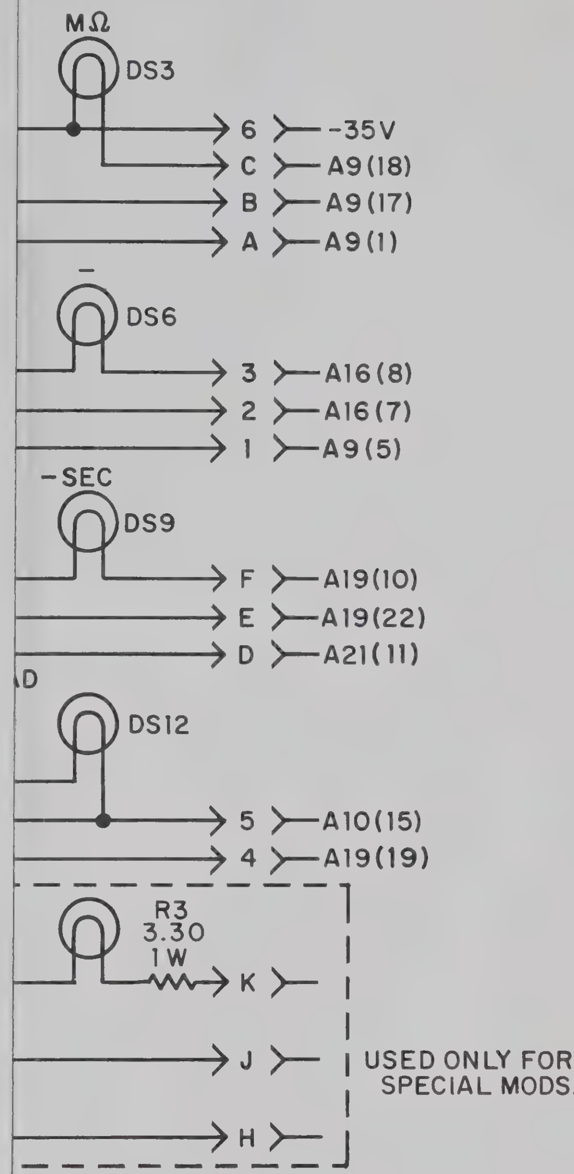
DY-2410B AC & OHMS DELAY GATE CIRCUIT (A23)

FIGURE 4.38

UNITS INDICATOR ASSEMBLY (A24)

5060-3818

FIGURE 4.39



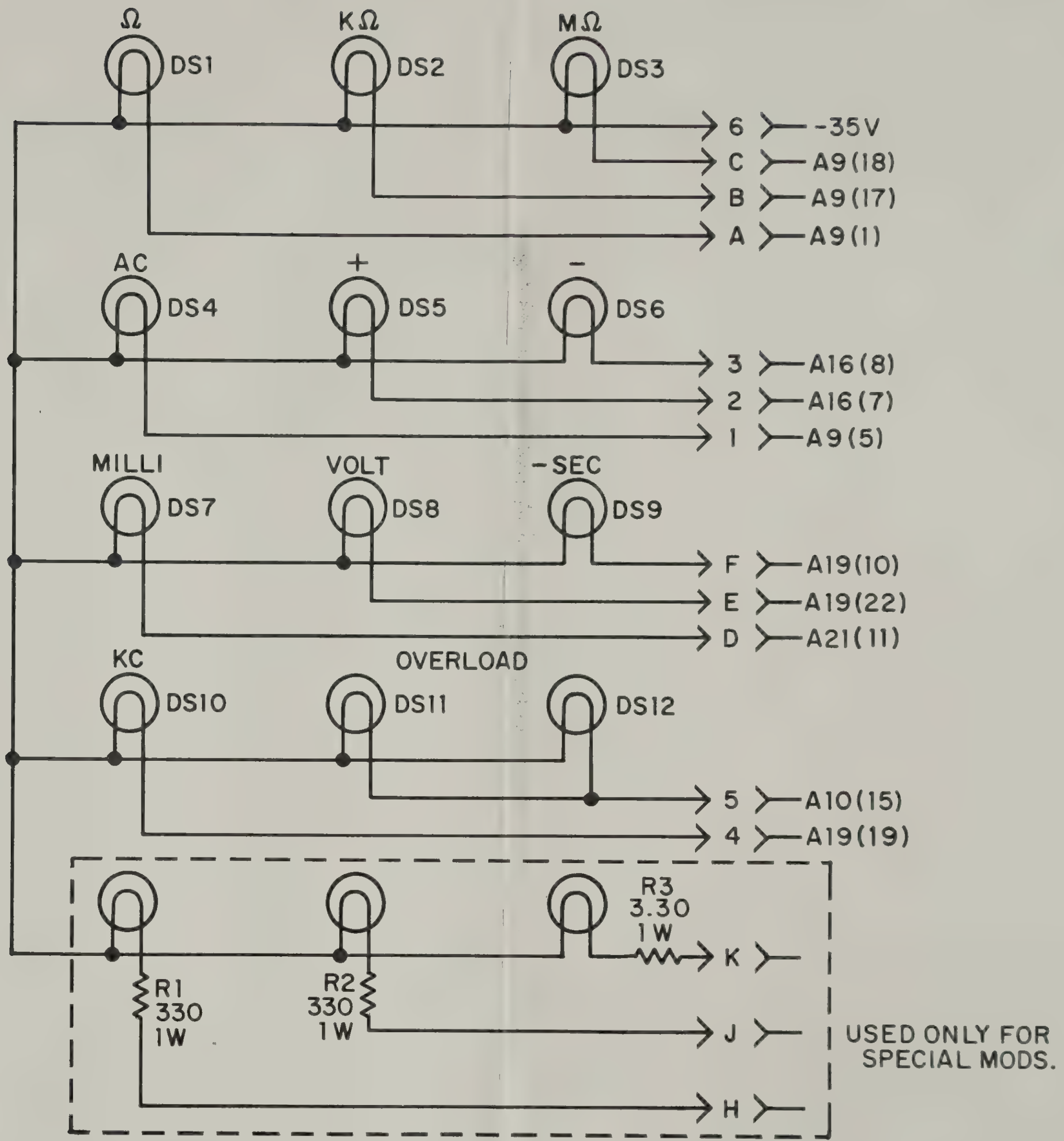
UNITS INDICATOR CIRCUIT (A24)

FIGURE 4.40

UNITS INDICATOR ASSEMBLY (A24)

5060-3818

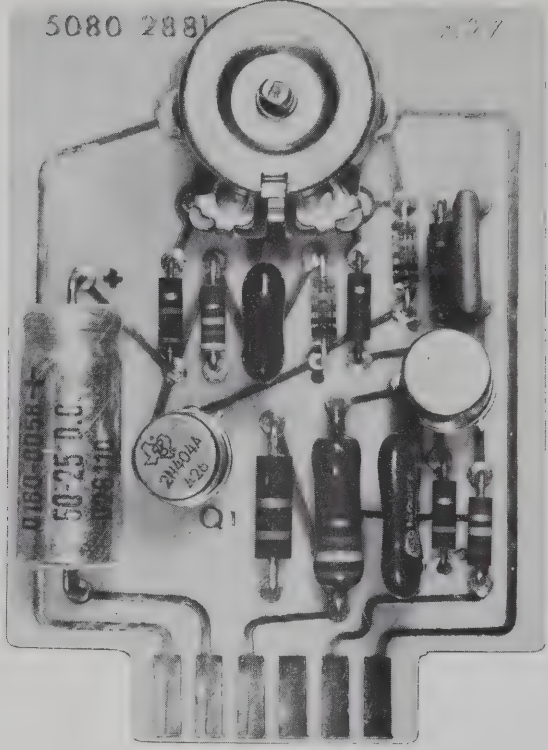
FIGURE 4.39

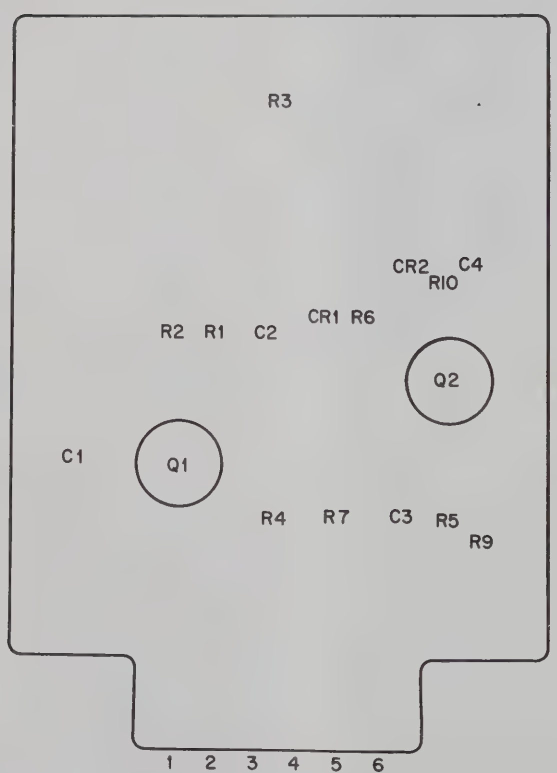


B5060-3818

UNITS INDICATOR CIRCUIT (A24)

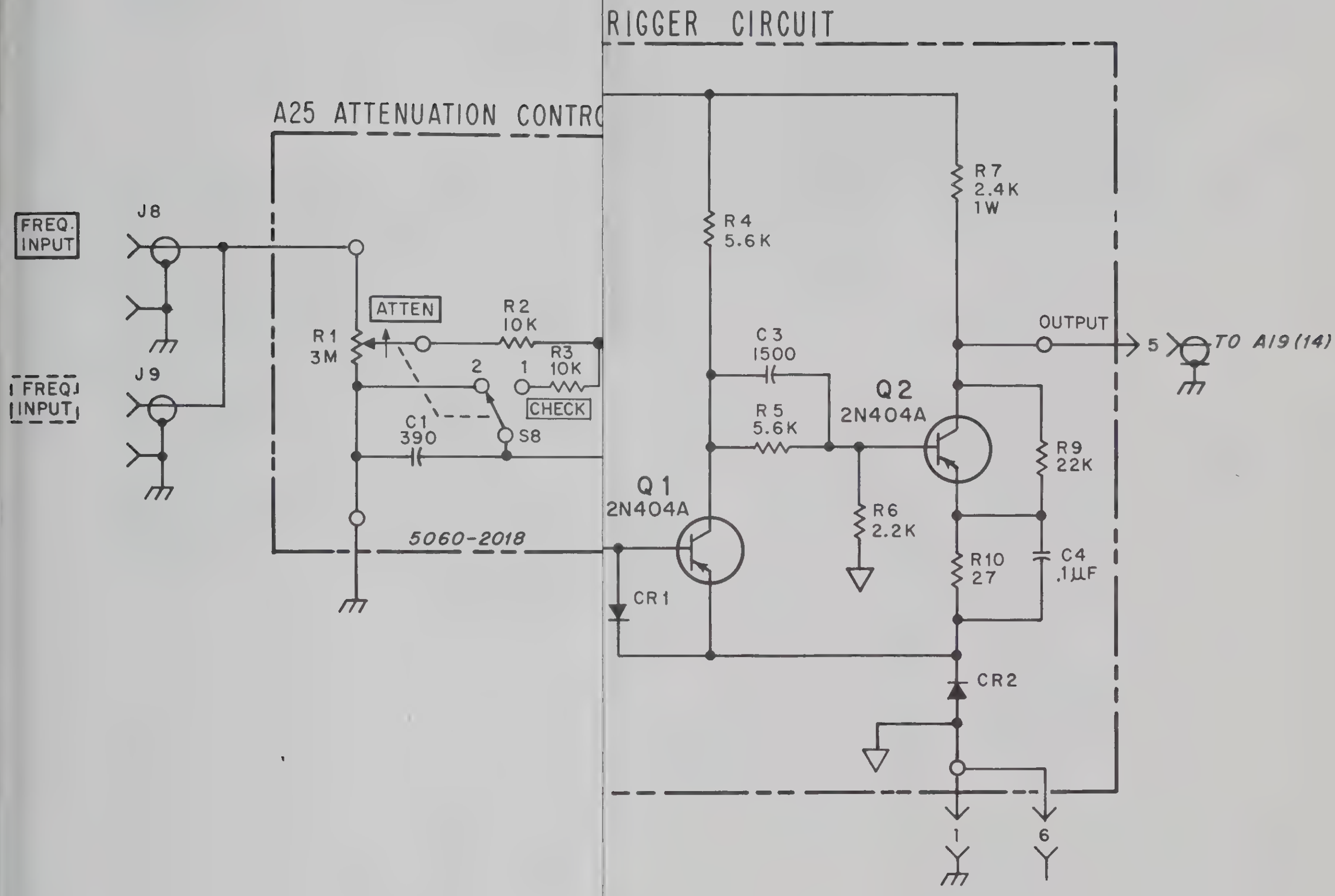
FIGURE 4.40





TRIGGER CIRCUIT ASSEMBLY (A27)
5060-5016

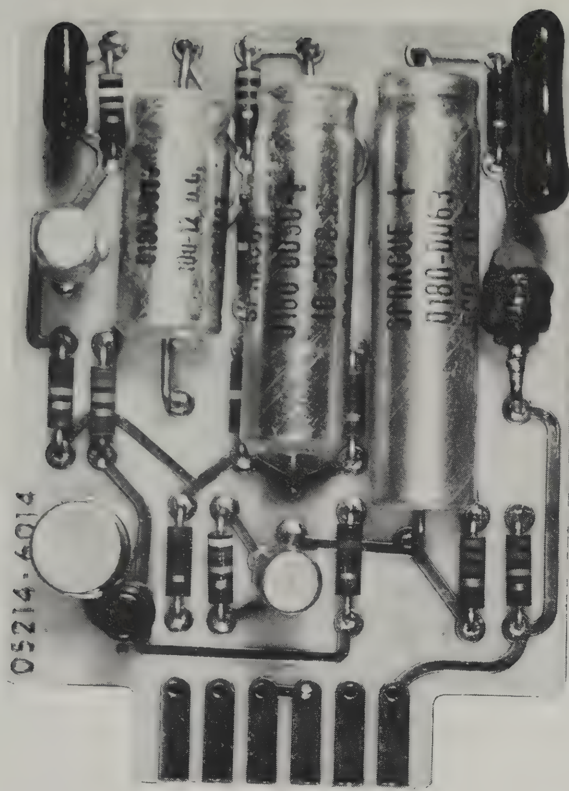
ASSEMBLIES A26 & A27
FIGURE 4.41

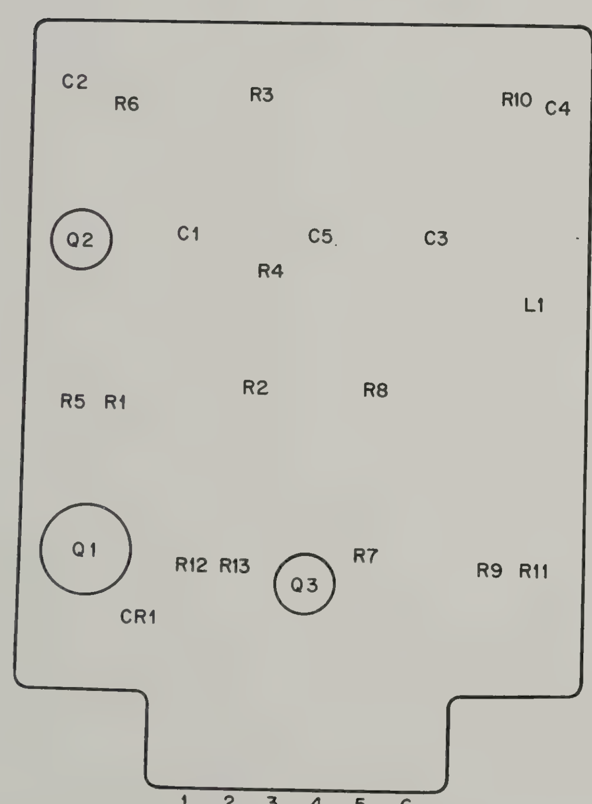


D5950-1525

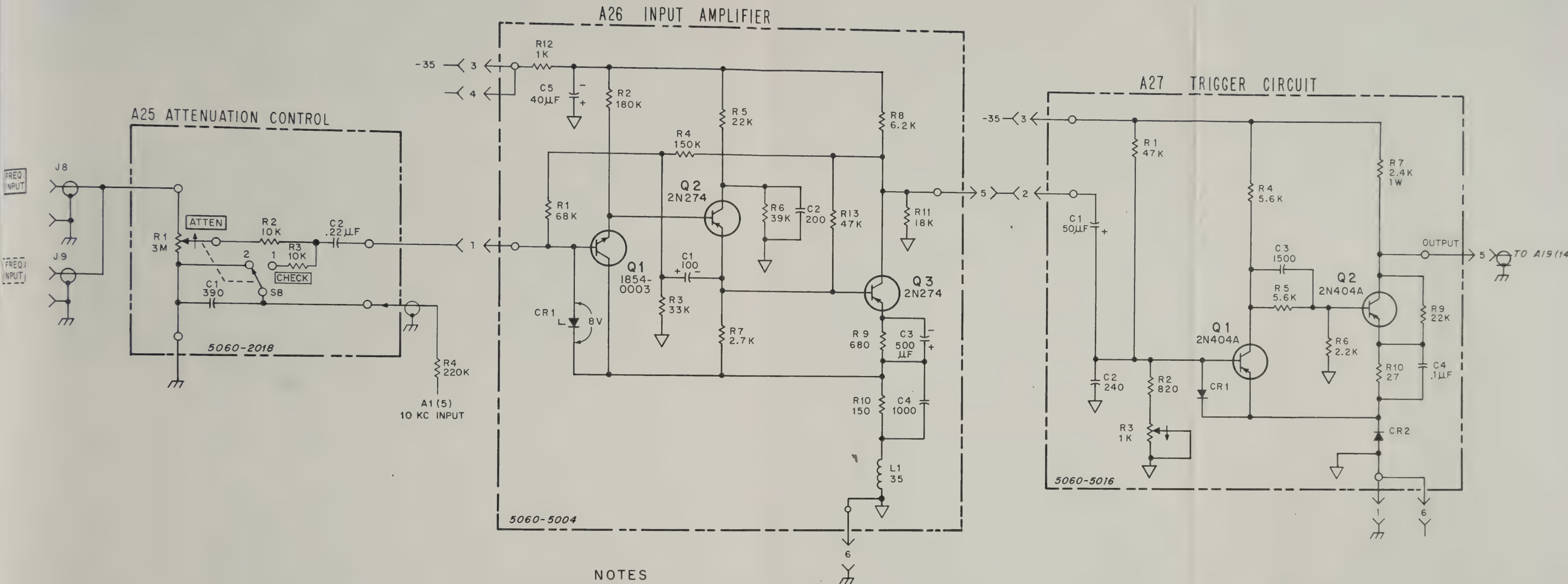
SENSITIVITY CONTROL, AMPLIFIER AND TRIGGER CIRCUITS (A25, A26 & A27)

FIGURE 4.42





INPUT AMPLIFIER ASSEMBLY (A26)
5214-6014 (5060-5004)



NOTES

1. UNLESS OTHERWISE INDICATED, RESISTANCE IN OHMS ± 5%, 1/4 W CAPACITANCE IN PICOFARADS, AND INDUCTANCE IN MICROHENRIES.

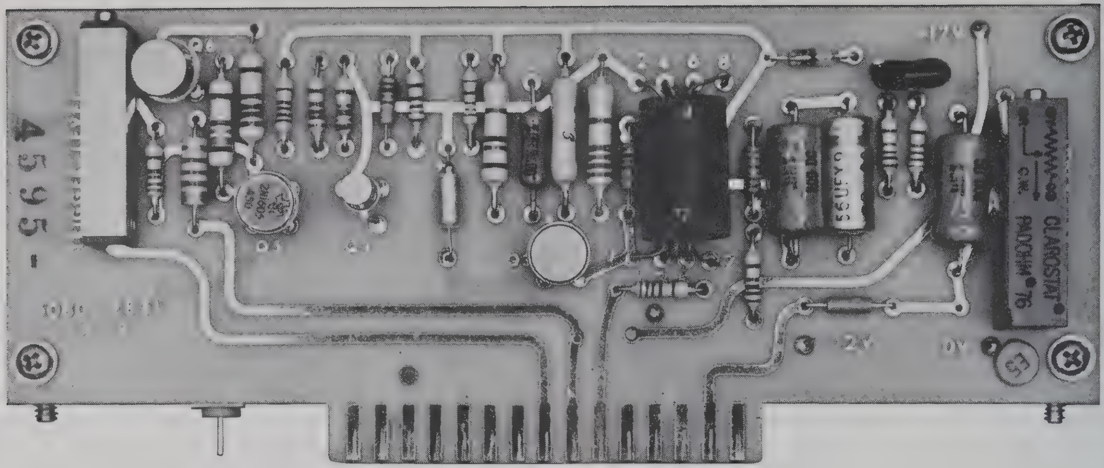
2. ▽ CIRCUIT COMMON

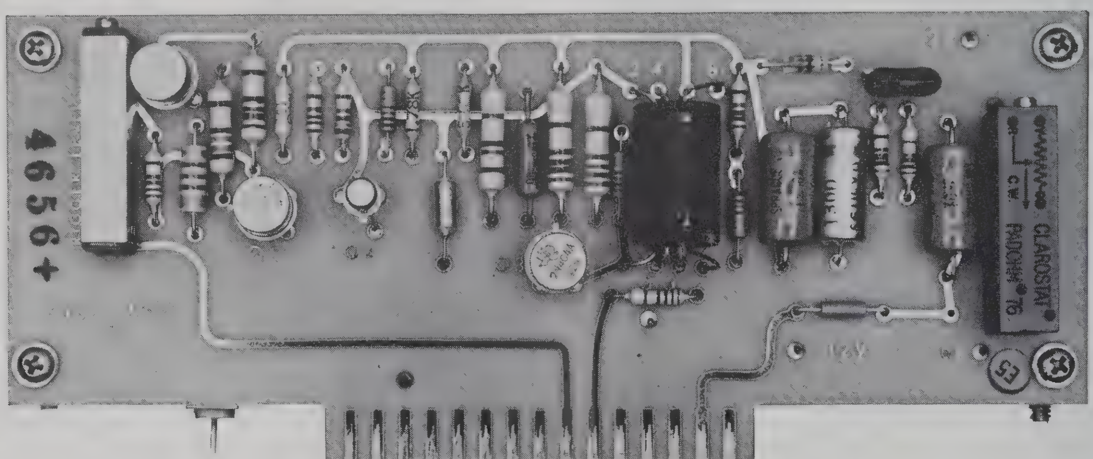
⏚ CHASSIS GROUND

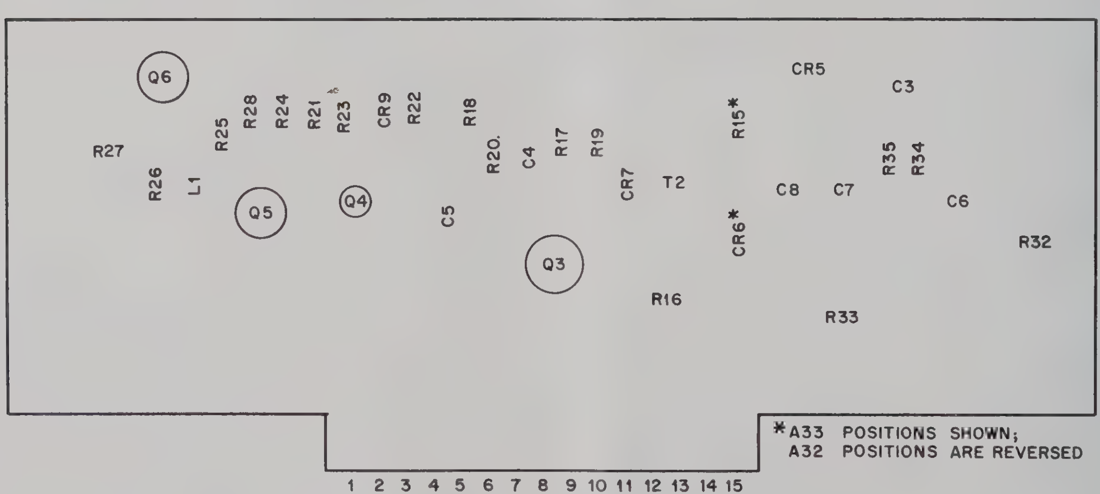
D5950-1525

SENSITIVITY CONTROL, AMPLIFIER AND TRIGGER CIRCUITS (A25, A26 & A27)

FIGURE 4.42







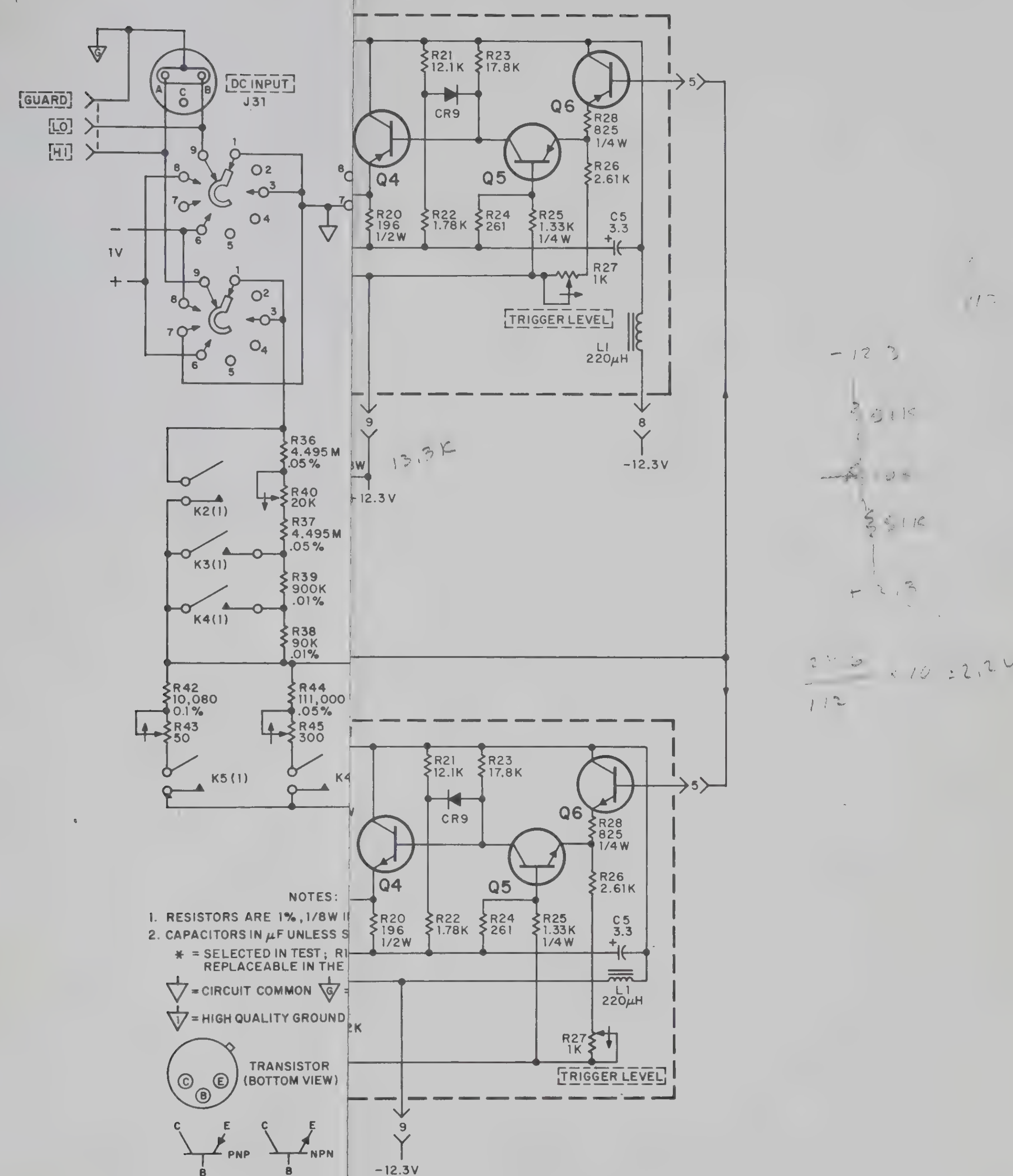
TRIGGER LEVEL DETECTOR ASSEMBLIES

NEGATIVE (A32) 5060-5001

POSITIVE (A33) 5060-3849

ASSEMBLIES A32 & A33

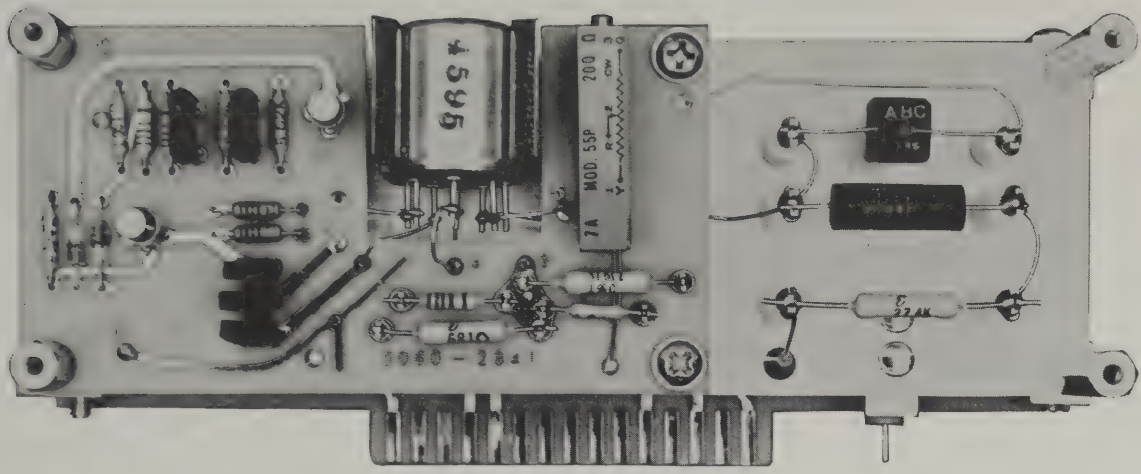
FIGURE 4.43

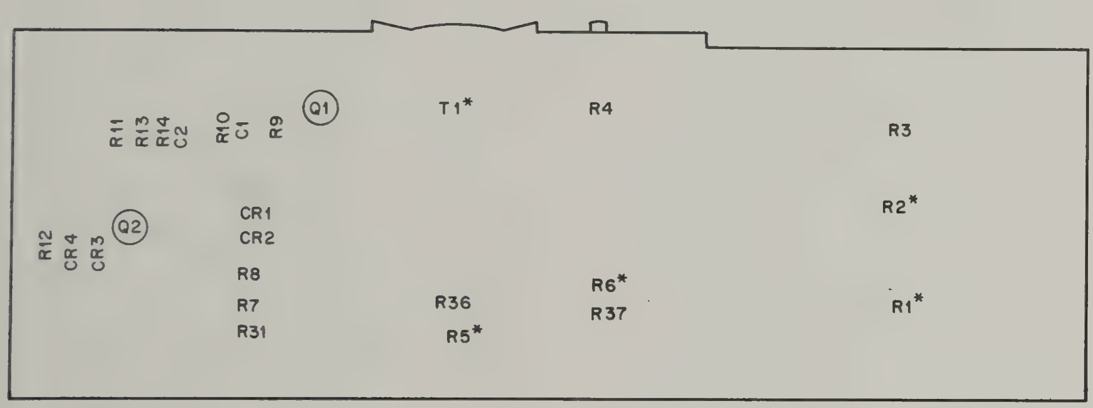


D5950-1526

PROGRAMMABLE ATTENUATOR AND V-F CONVERTER CIRCUIT (A28, A31, A32 & A33)

FIGURE 4.44

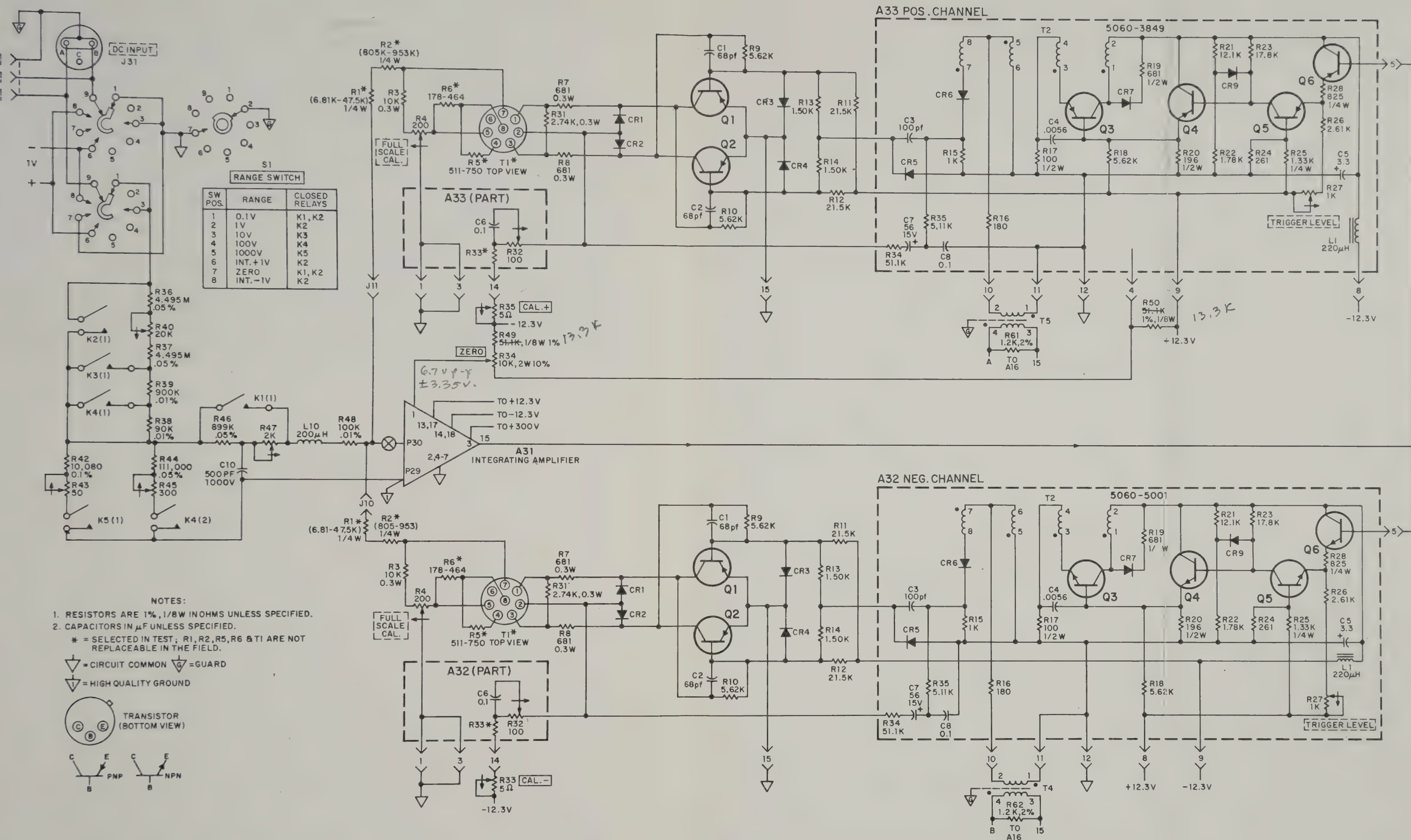




* Factory selected—not replaceable in the field

BINARY PRINTED CIRCUIT ASSEMBLY (A32A2 OR A33A2)

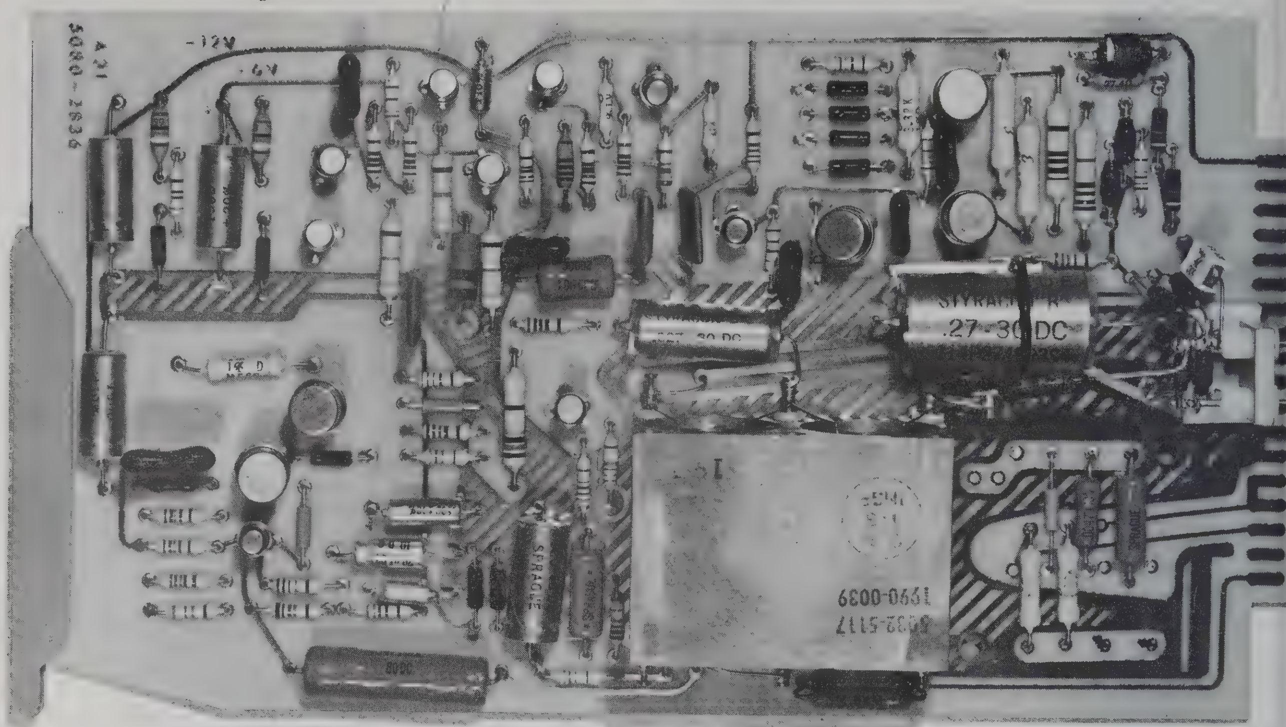
5060-3838

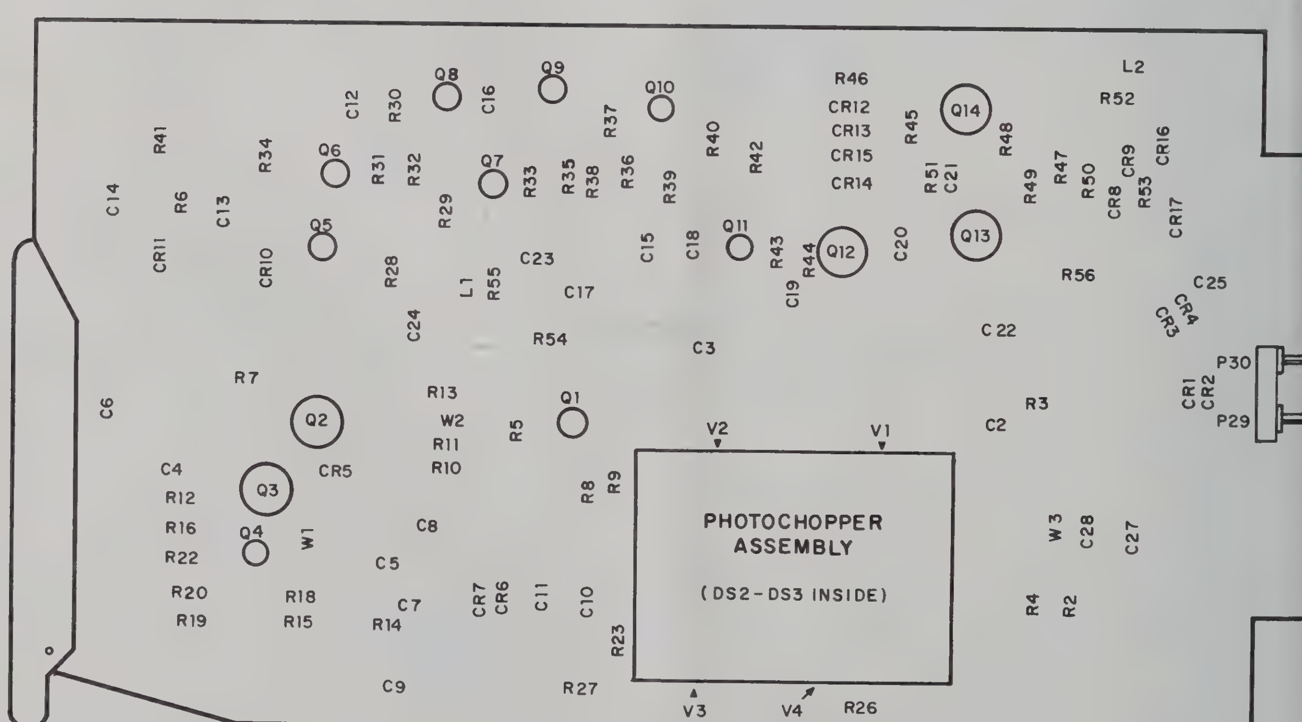


D5950-1526

PROGRAMMABLE ATTENUATOR AND V-F CONVERTER CIRCUIT (A28, A31, A32 & A33)

FIGURE 4.44

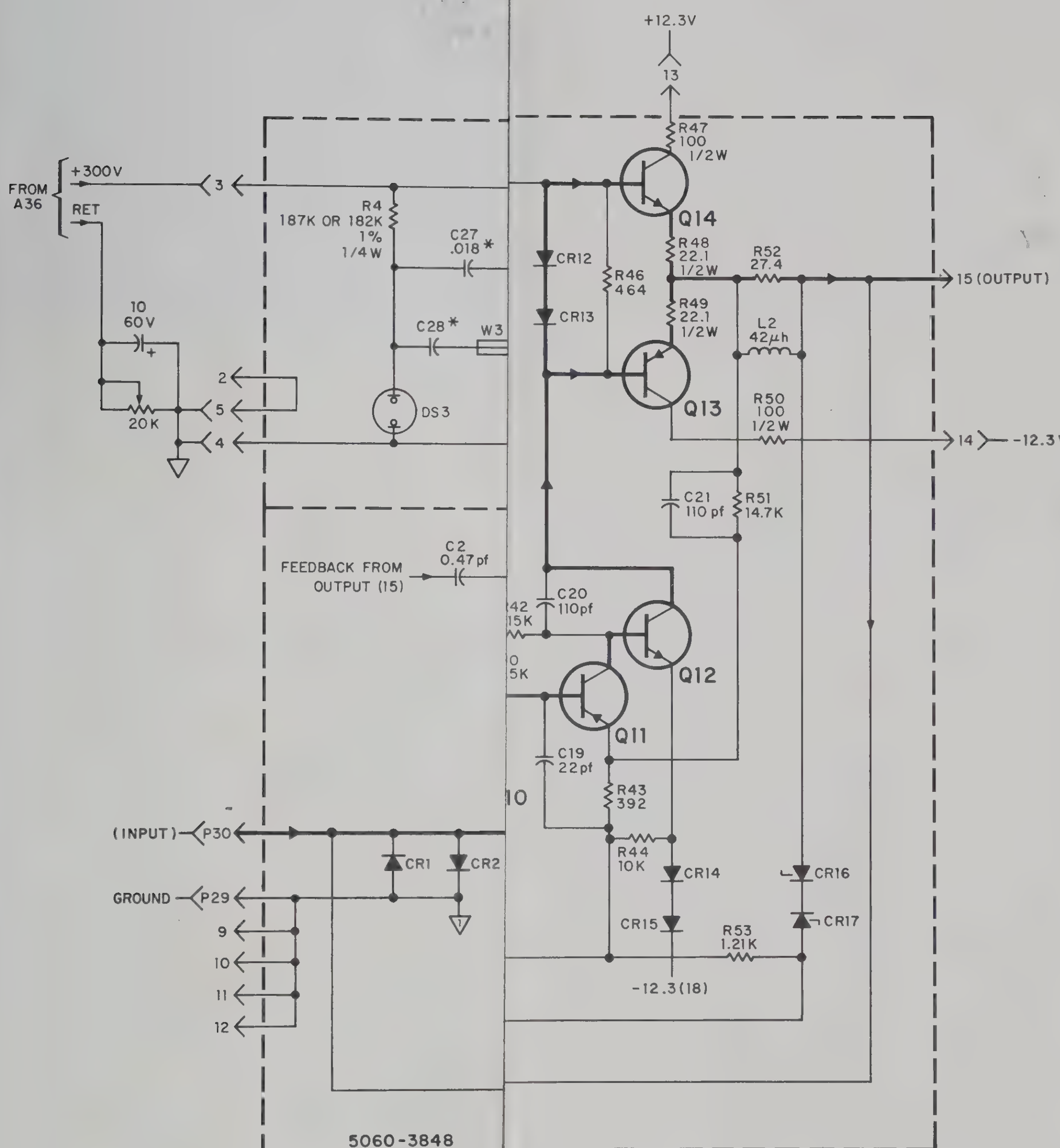




INTEGRATING OPERATIONAL AMPLIFIER ASSEMBLY (A31)

5060-3848

FIGURE 4.45



NOTES:
UNLESS OTHERWISE NOTED:

1. a. ALL RESISTORS 1/8W ± 5%
   b. ALL CAPACITANCE IN MICROFAR

* SELECTED FOR OSCILLATOR FRE

D5060-3848

ZERO POT : .475 ×6.5 = .62V p-p on base of Q5

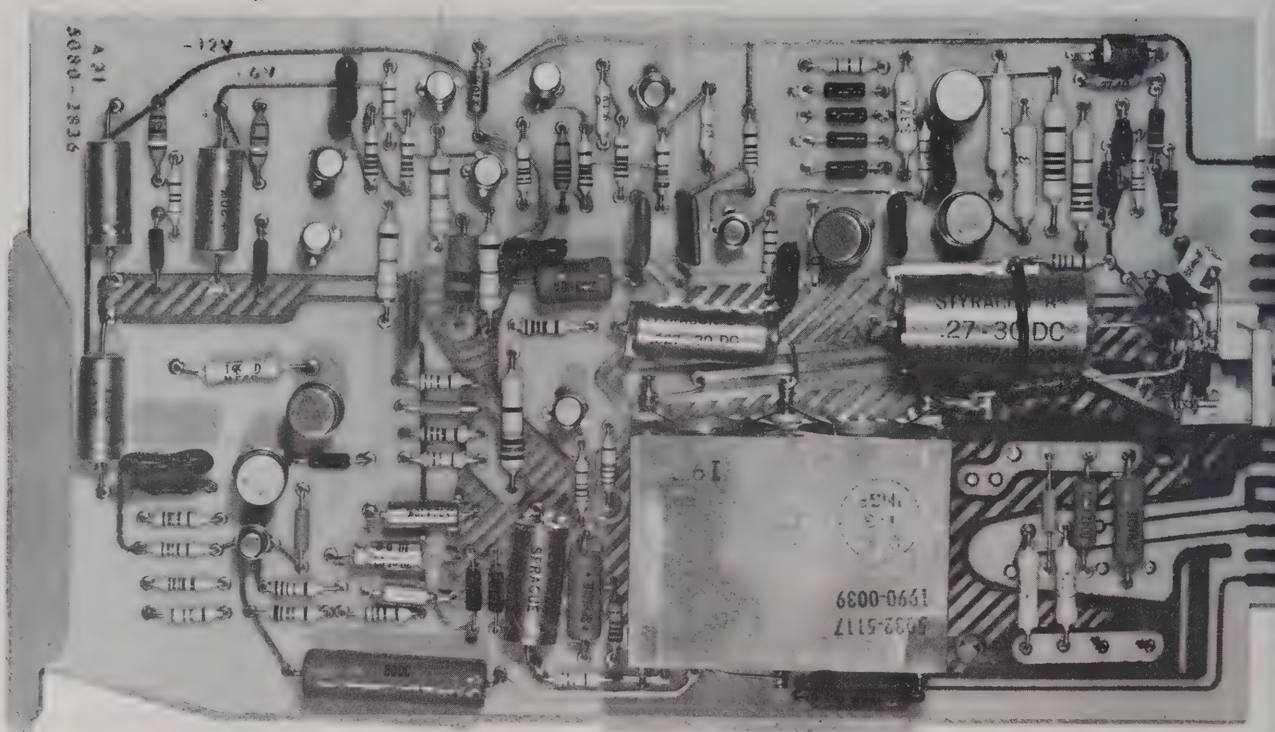
OR ±.5 μa p-p base of Q5

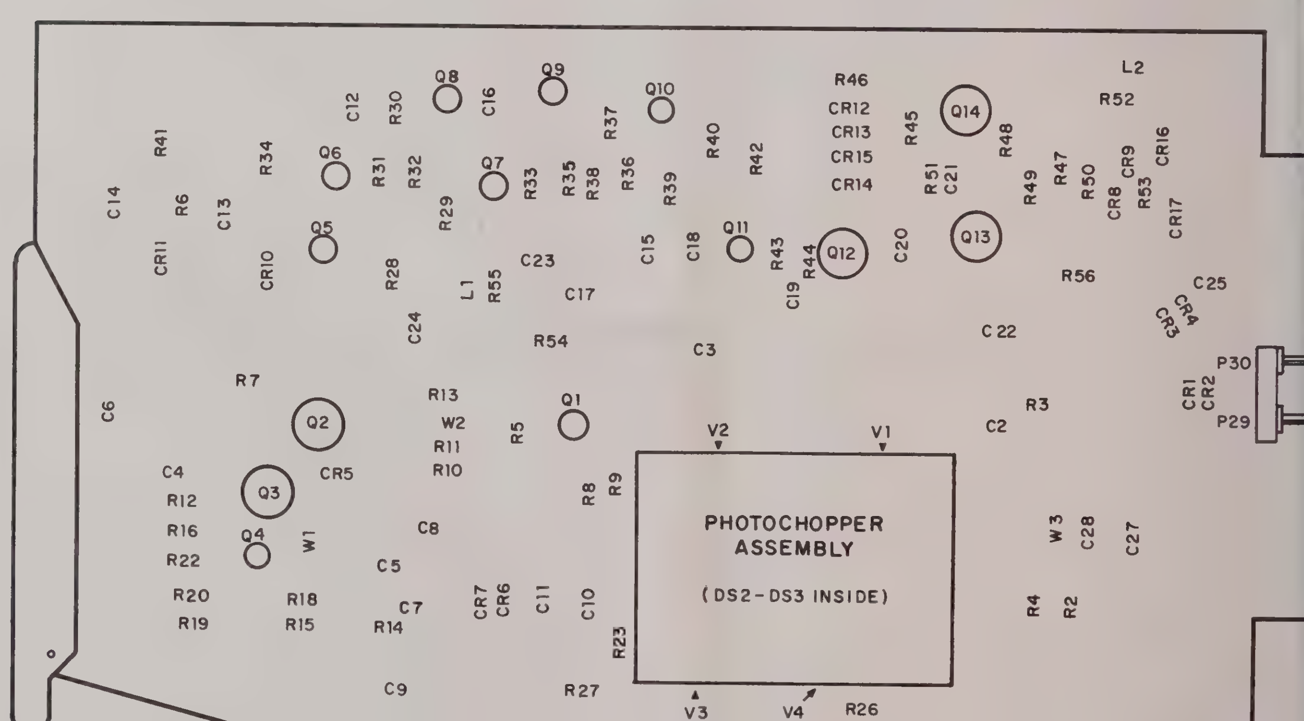
.2 μa | β=50

INTEGRATING AMPLIFIER CIRCUIT (A31)

FIGURE 4.46

± 286 mv (572 mv p-p) on pot.

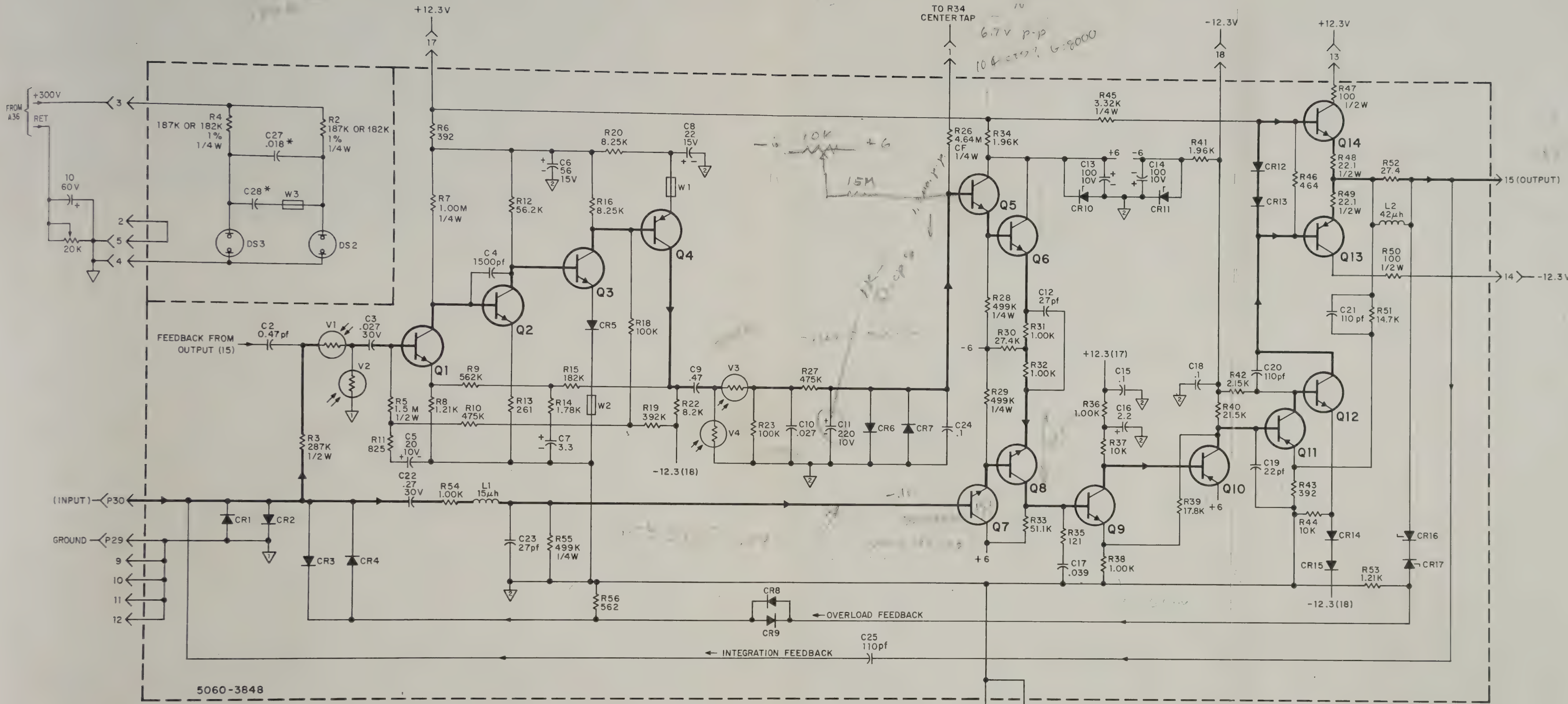




INTEGRATING OPERATIONAL AMPLIFIER ASSEMBLY (A31)

5060-3848

FIGURE 4.45



NOTES:
UNLESS OTHERWISE NOTED:

1. a. ALL RESISTORS 1/8 W ±5%
   b. ALL CAPACITANCE IN MICROFARADS

* SELECTED FOR OSCILLATOR FREQUENCY OF 240 CPS

D5060-3848

ZERO POT : $\frac{.475}{4.64+.475} \times 6.7 = .62V$ p-p on base of Q5
5.115

OR ±.7 μa p-p at base of Q5

Ib max = .2 μa | β=50

Remove CR6, CR7

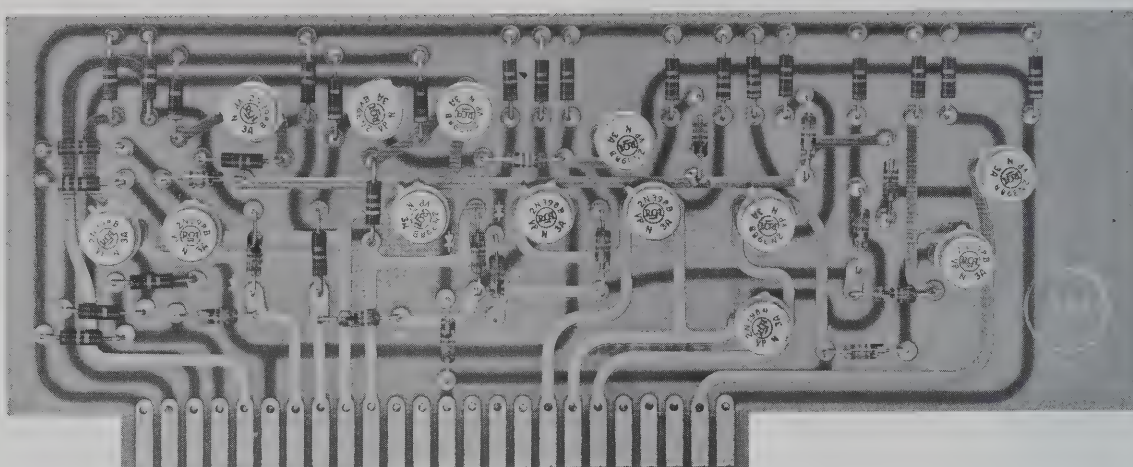
+240

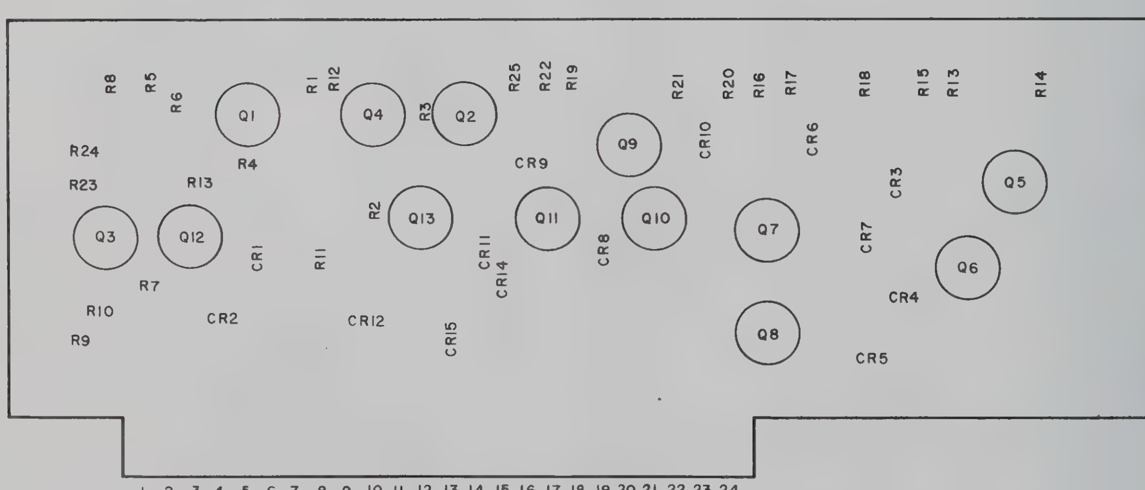
Q1, Q5-8 1854-0025

INTEGRATING AMPLIFIER CIRCUIT (A31)

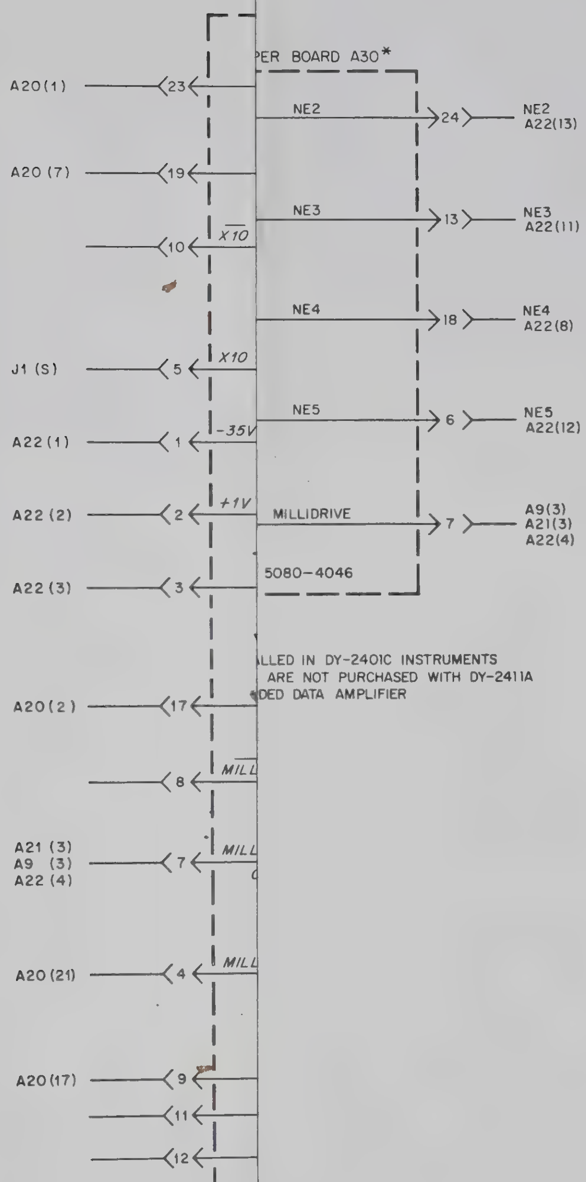
FIGURE 4.46

This leaves ±286 mv (572 mv after) on pot





DY-2411A DECIMAL POINT
LOGIC CARD (A30)
5060-2108
FIGURE 4.47

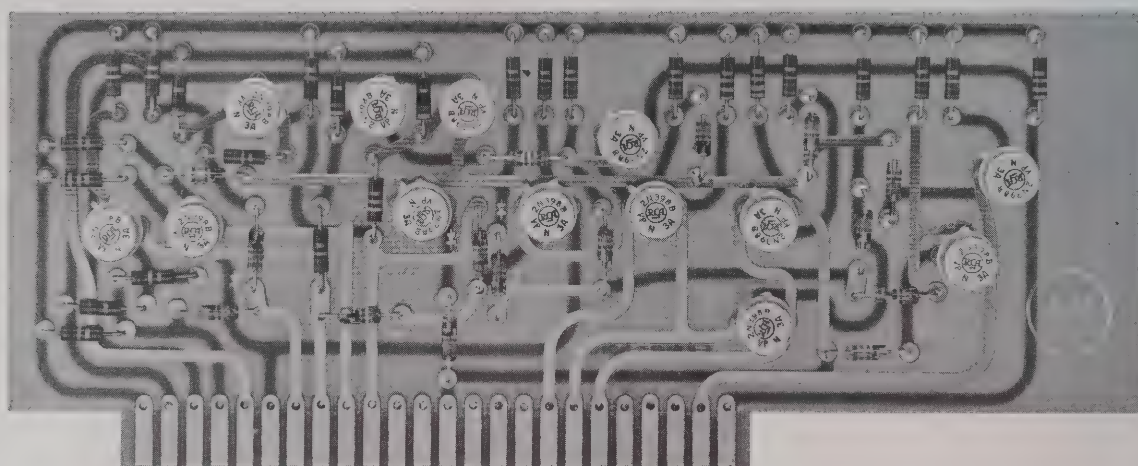


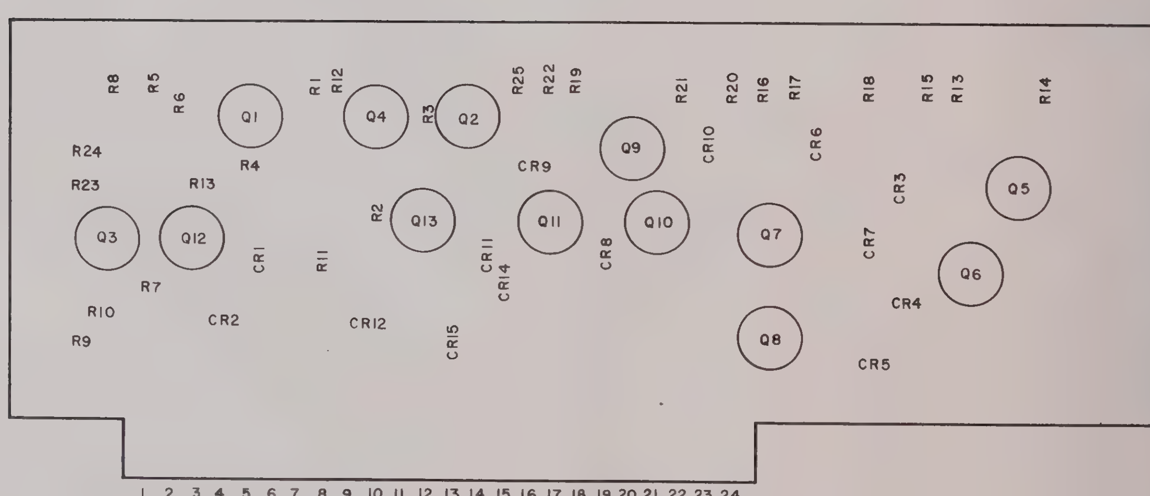
UNLESS OTHERWISE SPECIFIED
ALL RESISTANCE IN OHMS, 5
ALL TRANSISTORS 2N3988.

D5060-2108

DY-2411A DECIMAL POINT LOGIC CIRCUIT (A30)

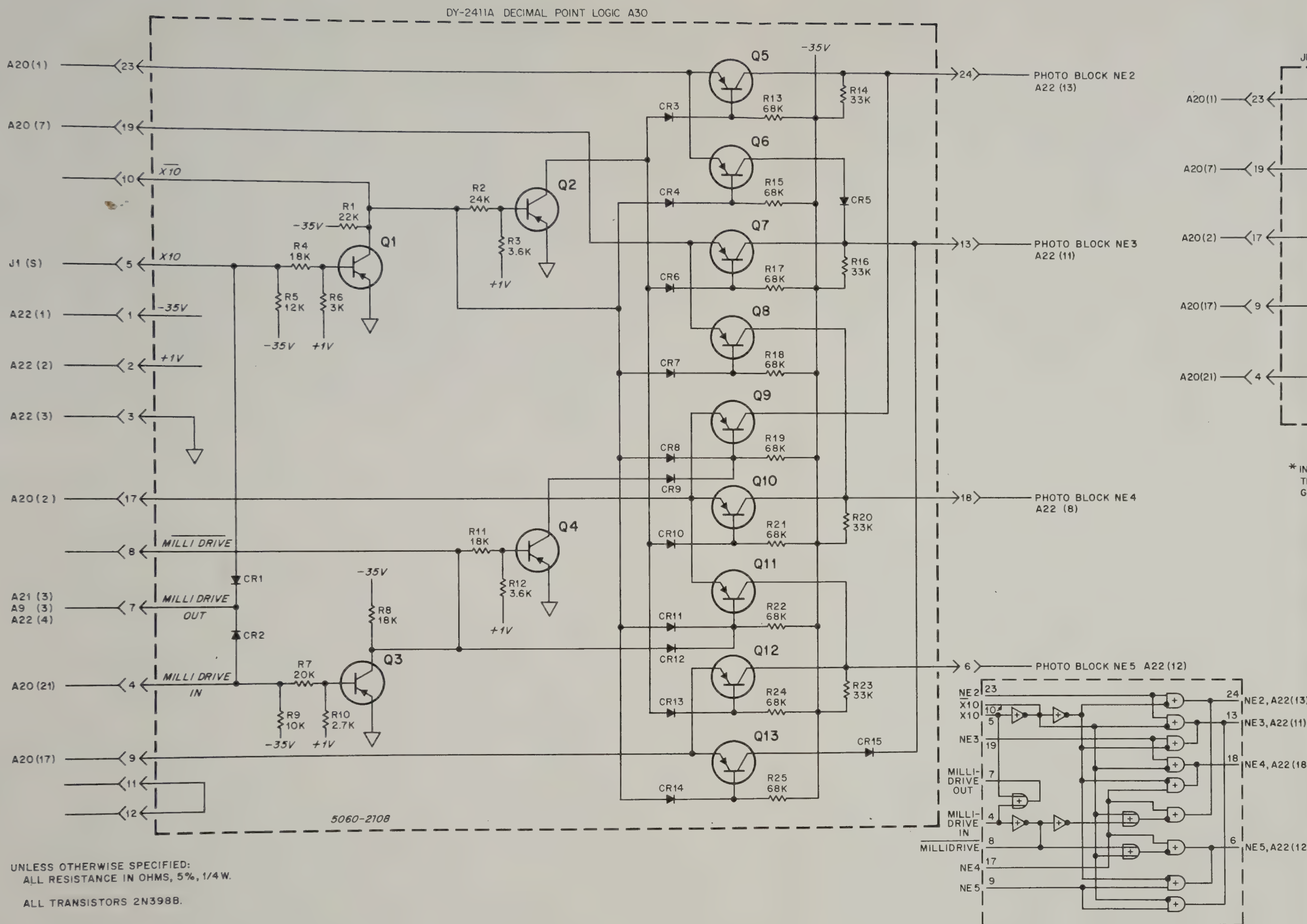
FIGURE 4.48

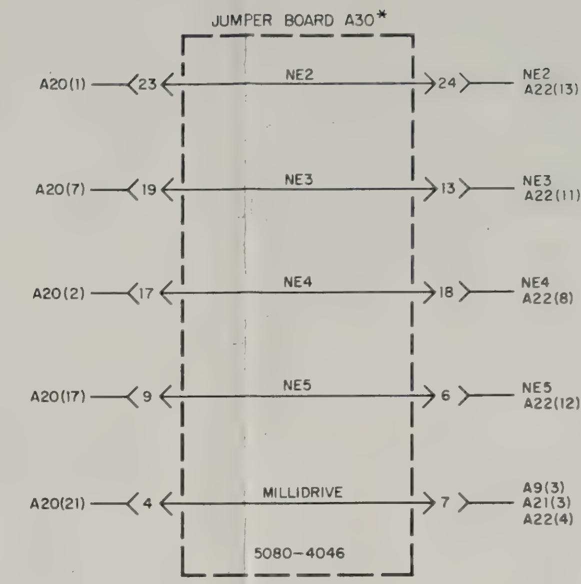




DY-2411A DECIMAL POINT
LOGIC CARD (A30)

5060-2108
FIGURE 4.47





* INSTALLED IN DY-2401C INSTRUMENTS THAT ARE NOT PURCHASED WITH DY-2411A GUARDED DATA AMPLIFIER

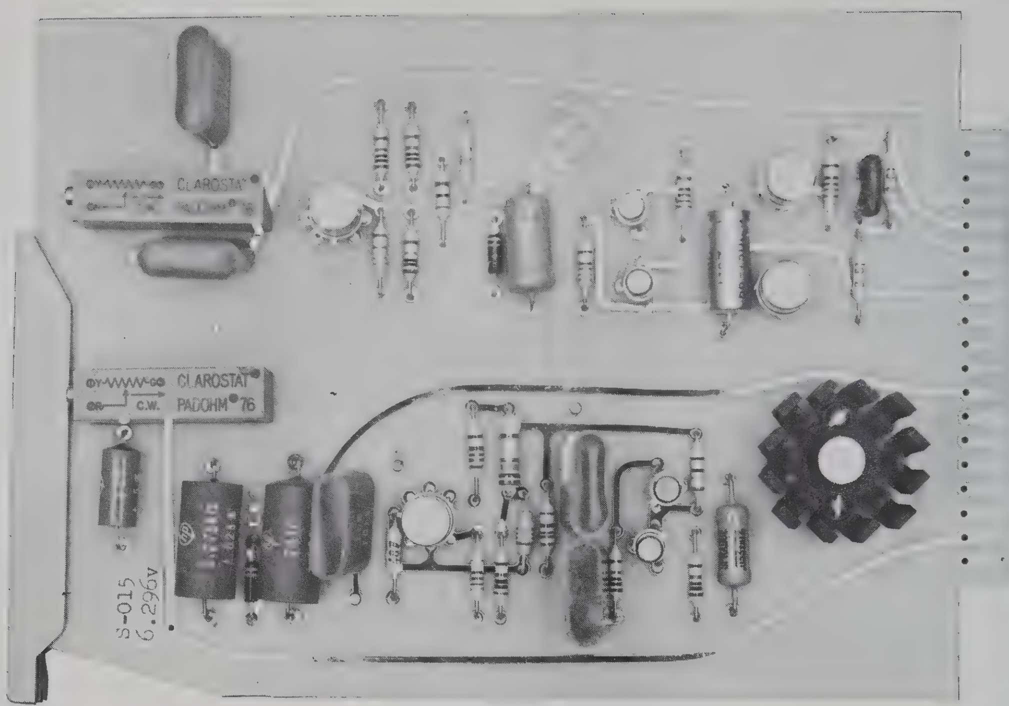
UNLESS OTHERWISE SPECIFIED:
ALL RESISTANCE IN OHMS, 5%, 1/4W.

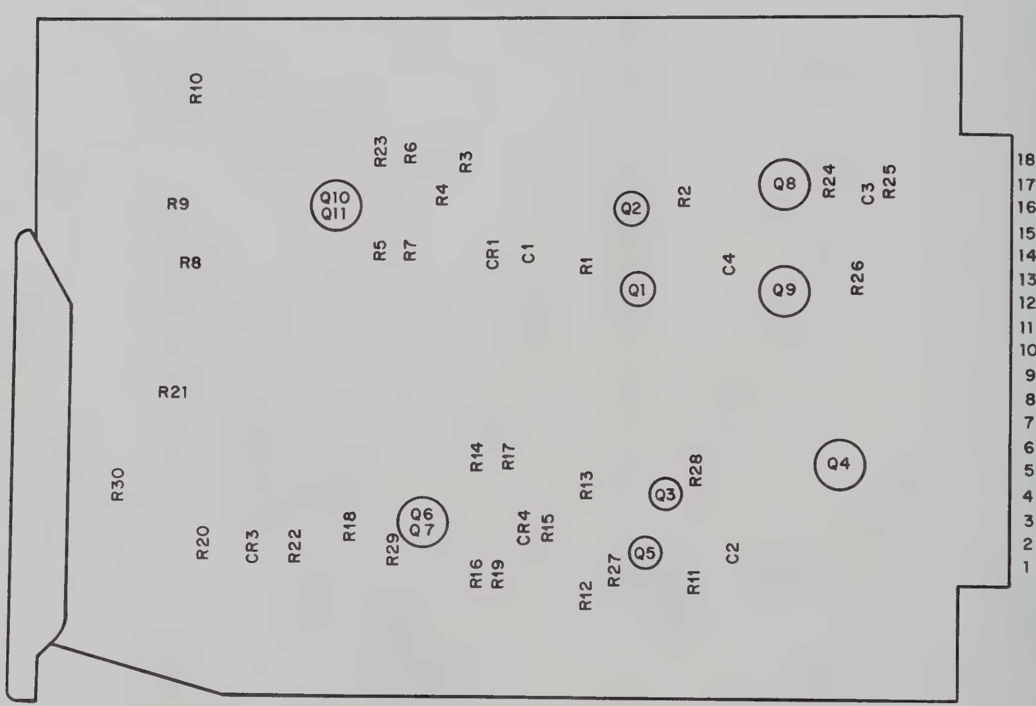
ALL TRANSISTORS 2N398B.

D5060-2108

DY-2411A DECIMAL POINT LOGIC CIRCUIT (A30)

FIGURE 4.48





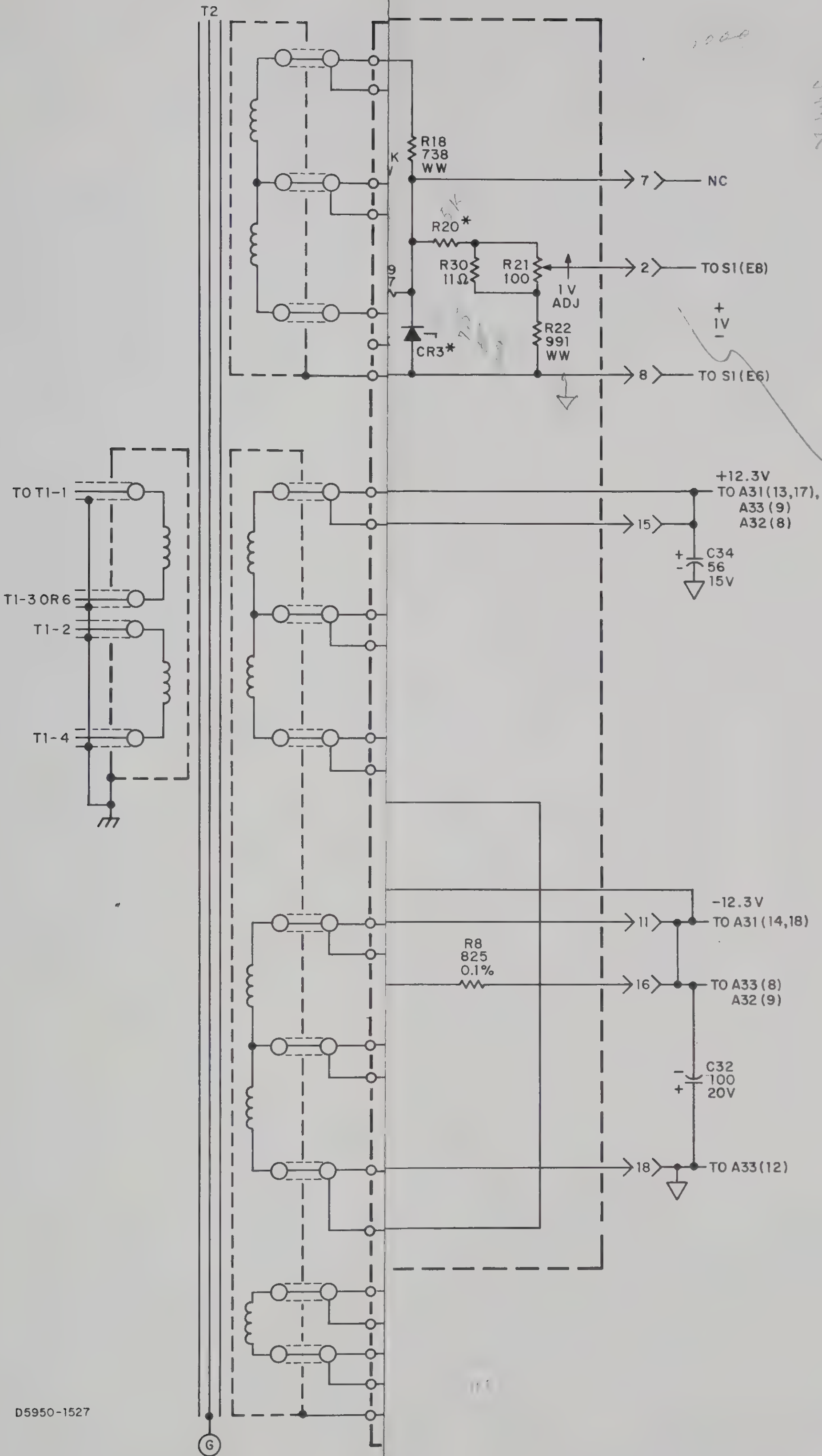
CALIBRATION STANDARD AND POWER SUPPLY AMPLIFIER ASSEMBLY (A35)

5060-3783

ASSEMBLIES A34, A35 & A36

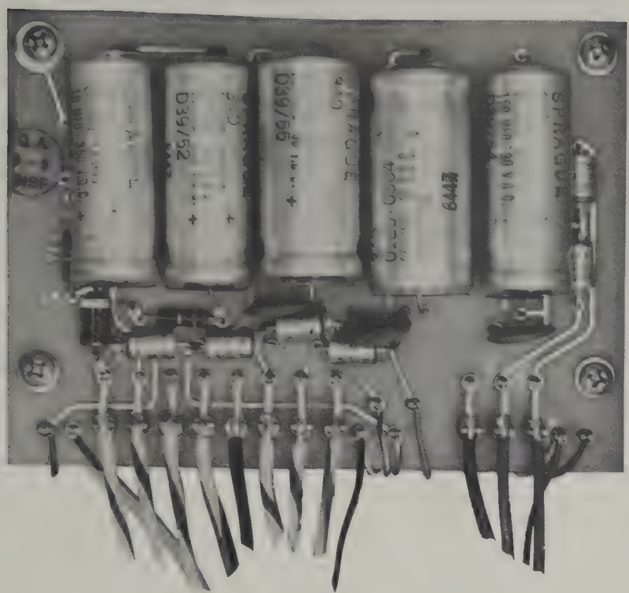
FIGURE 4.49

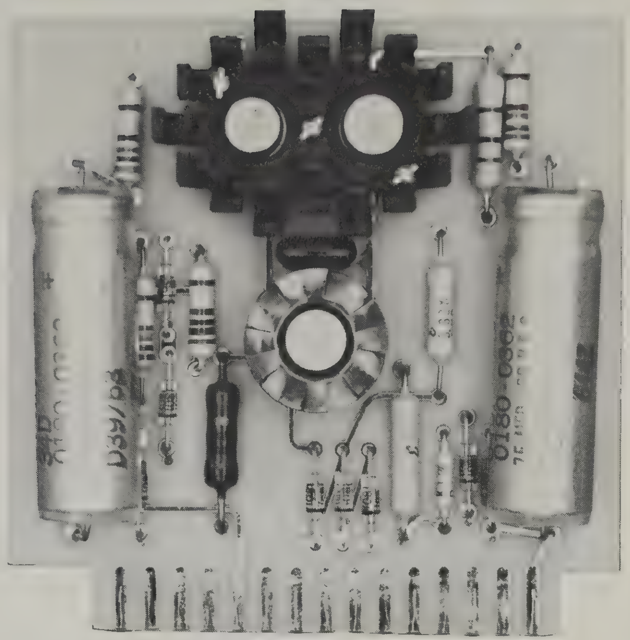
osc. freq. MC's - 10mc

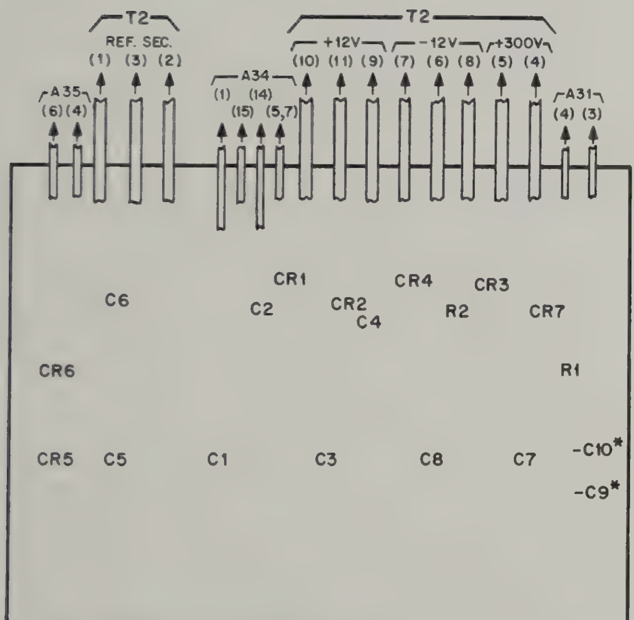


POWER SUPPLY CIRCUIT
(A34, A35 & A36)

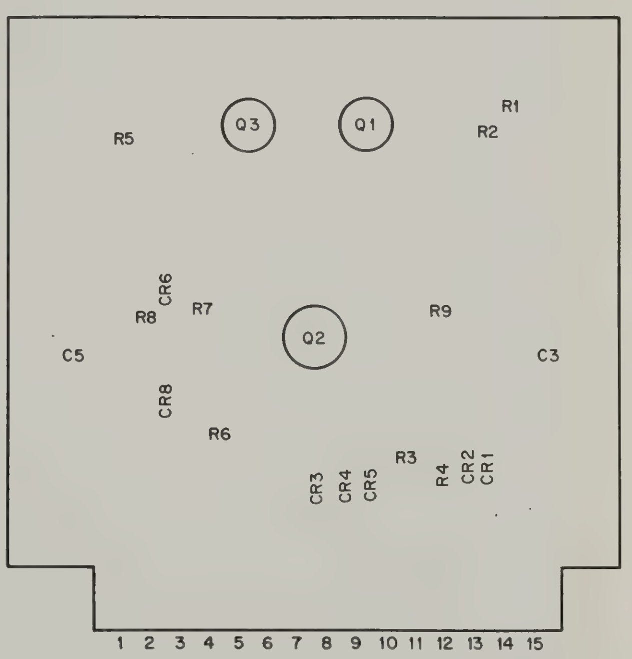
FIGURE 4.50





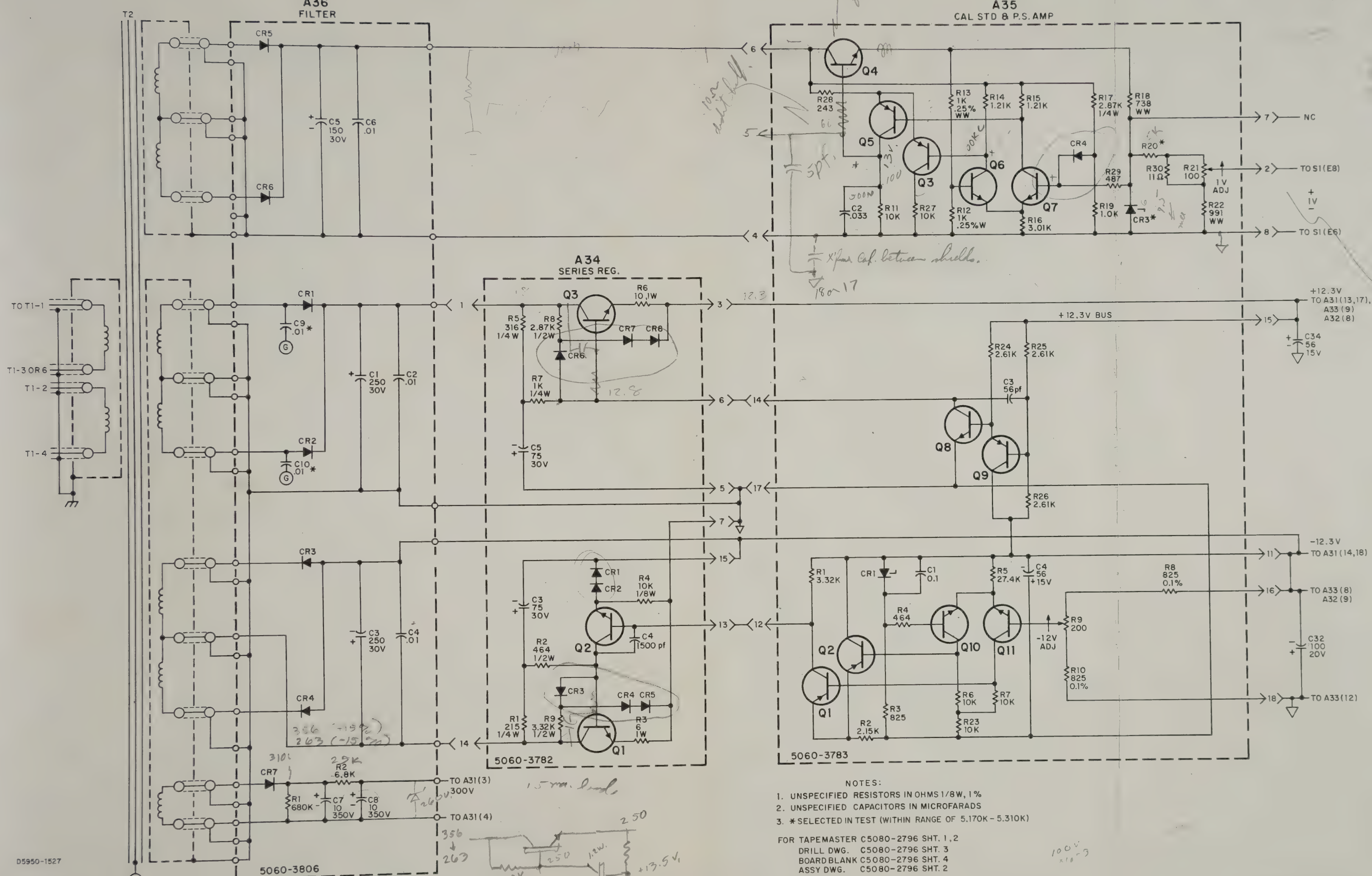


*May be installed after selection by test



FILTER BOARD (A36)
5060-3806

SERIES REGULATOR ASSEMBLY (A34)
5060-3782



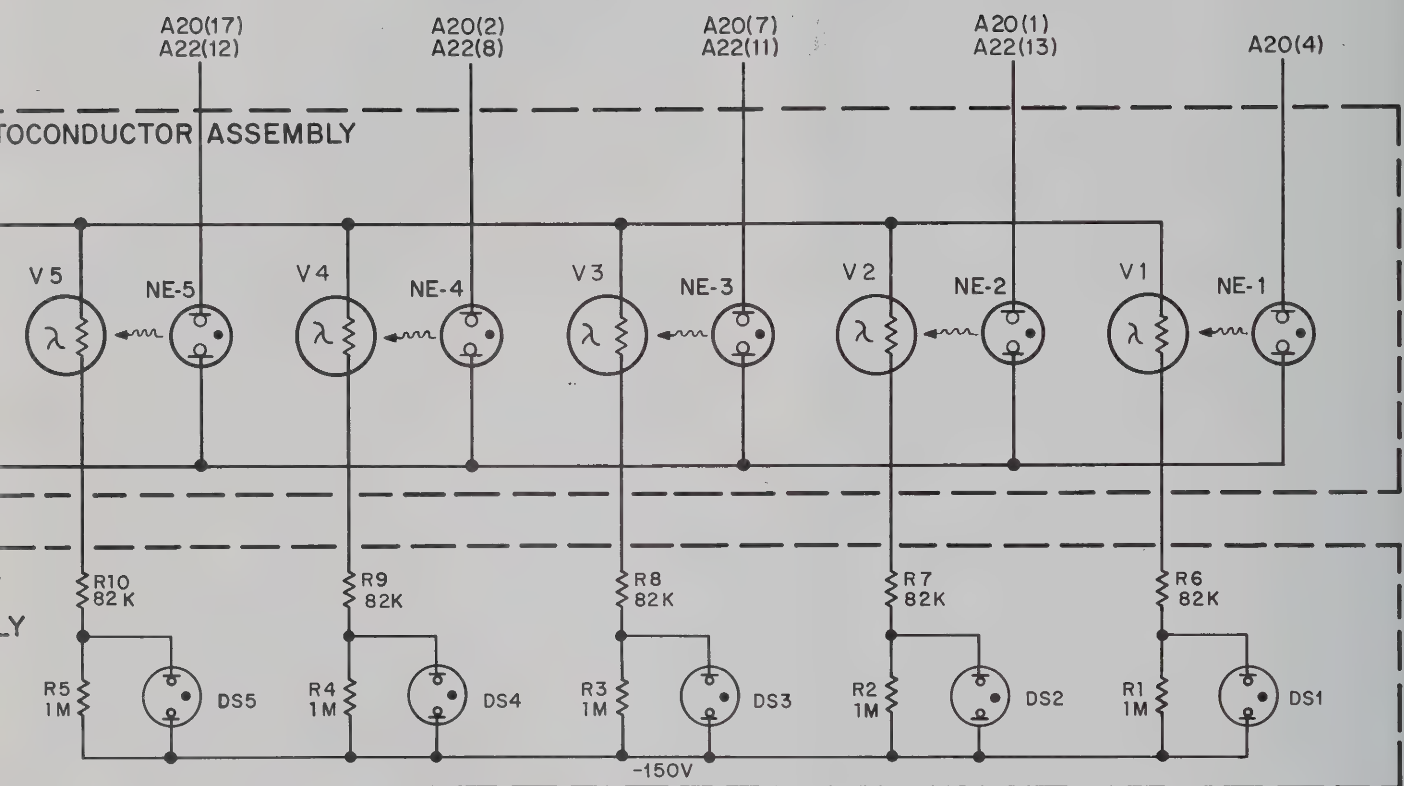
NOTES:

1. UNSPECIFIED RESISTORS IN OHMS 1/8W, 1%
2. UNSPECIFIED CAPACITORS IN MICROFARADS
3. * SELECTED IN TEST (WITHIN RANGE OF 5.170K – 5.310K)

FOR TAPEMASTER C5080-2796 SHT. 1, 2
DRILL DWG. C5080-2796 SHT. 3
BOARD BLANK C5080-2796 SHT. 4
ASSY DWG. C5080-2796 SHT. 2

POWER SUPPLY CIRCUIT (A34, A35 & A36)

FIGURE 4.50



PHOTOCONDUCTOR AND DECIMAL LAMP CIRCUIT

FIGURE 4.51

SECTION 5
TABLE OF REPLACEABLE PARTS

5.1 INTRODUCTION

This section contains identification and ordering information for replacement parts. Any changes to the Table of Replaceable Parts will be listed on a Change Sheet at the front of this handbook. Note that Dymec uses (hp) stock numbers. A part described as (hp) only is a special part that can be obtained only from the Hewlett-Packard Co. If another manufacturer's stock (part) number is listed, the part may be obtained directly from that manufacturer. A list of manufacturers' code numbers will be found in the Appendix at the end of the Table. In general, parts available from manufacturers other than those listed may be used if the part has equivalent electrical and physical characteristics and quality.

As noted on schematic diagrams, the optimum electrical value of certain components may be selected at the factory to compensate for variations in other components, wiring capacitance, etc. In some instruments, a selected part may be omitted (e.g., a selected resistor might be a wire or an open circuit). The nominal (or average) value of the part is indicated on the schematic diagram. When replacing, use the original value of the part installed in your instrument.

The Table lists parts in alpha-numerical order of their reference designation and provides the following information on each part:

1. Description (see list of abbreviations used, paragraph 5.3).
2. (hp) stock number or Dymec drawing number.
3. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).
4. Manufacturer's part, stock, or drawing number.
5. Total quantity used in instrument.
6. Recommended spare part quantity for complete maintenance during one year of isolated service.

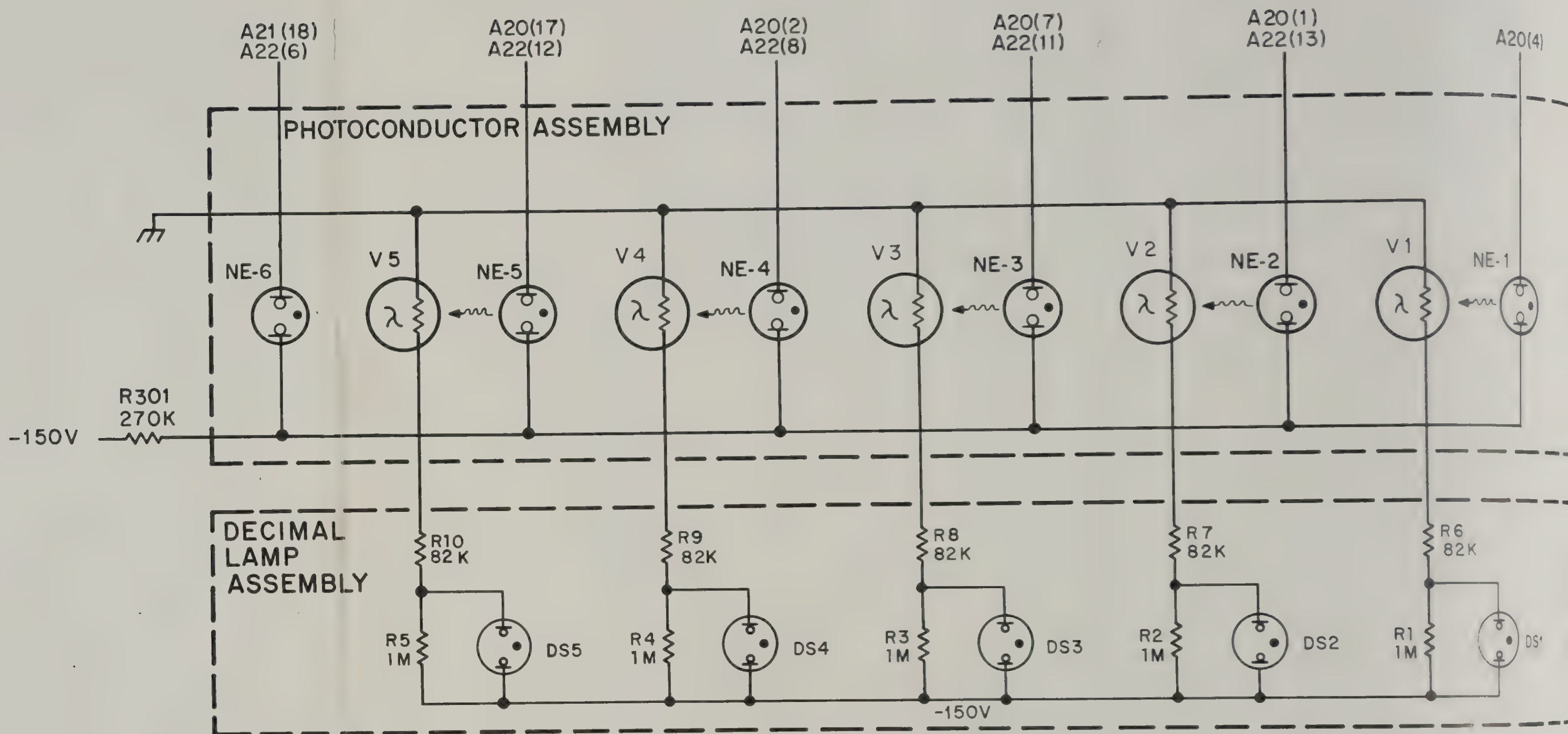
Miscellaneous and mechanical parts not indexed by reference designation are listed at the end of the Table.

5.2 ORDERING INFORMATION

To order a replacement part, address your order or inquiry either to your local Hewlett-Packard/Dymec field office (listed on last page of this handbook) or to:

United States
CUSTOMER SERVICE
Hewlett-Packard Co.
395 Page Mill Road
Palo Alto, California

Western Europe
Hewlett-Packard S. A.
54 Route des Acacias
Geneva, Switzerland



PHOTOCONDUCTOR AND DECIMAL LAMP CIRCUIT

FIGURE 4.51

SECTION 5
TABLE OF REPLACEABLE PARTS

.1 INTRODUCTION

This section contains identification and ordering information for replacement parts. Any changes to the Table of Replaceable Parts will be listed on a Change Sheet at the front of this handbook. Note that Dymec uses ⓗⓟ stock numbers. A part described as ⓗⓟ only is a special part that can be obtained only from the Hewlett-Packard Co. If another manufacturer's stock (part) number is listed, the part may be obtained directly from that manufacturer. A list of manufacturers' code numbers will be found in the Appendix at the end of the Table. In general, parts available from manufacturers other than those listed may be used if the part has equivalent electrical and physical characteristics and quality.

As noted on schematic diagrams, the optimum electrical value of certain components may be selected at the factory to compensate for variations in other components, wiring capacitance, etc. In some instruments, a selected part may be omitted (e.g., a selected resistor might be a wire or an open circuit). The nominal (or average) value of the part is indicated on the schematic diagram. When replacing, use the original value of the part installed in your instrument.

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1. Description (see list of abbreviations used, paragraph 5.3).
2. ⓗⓟ stock number or Dymec drawing number.
3. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).
4. Manufacturer's part, stock, or drawing number.
5. Total quantity used in instrument.
6. Recommended spare part quantity for complete maintenance during one year of isolated service.

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United States
CUSTOMER SERVICE
Hewlett-Packard Co.
395 Page Mill Road
Palo Alto, California

Western Europe
Hewlett-Packard S. A.
54 Route des Acacias
Geneva, Switzerland

Specify the following information on each part:

1. Dymec model number and complete serial number of instrument.
2. ⓗⓟ stock number.
3. Circuit reference designation.
4. Description.

To order a part not listed in the Table, give complete description and include function and location of the part in the instrument and/or system.

5.3 ABBREVIATIONS USED

Reference Designation Column

A	= assembly	MP	= mechanical part
B	= motor	P	= plug
C	= capacitor	Q	= transistor
CR	= diode	R	= resistor
DL	= delay line	RT	= thermistor
DS	= device signaling (lamp)	RV	= varistor
E	= misc electronic part	S	= switch
F	= fuse	T	= transformer
FL	= filter	V	= vacuum tube, neon bulb, photo-cell, etc.
J	= jack	W	= cable
K	= relay	X	= socket
L	= inductor	Z	= network
M	= meter		

Description Column

a	= amperes	pos	= position(s)
c	= carbon	poly	= polystyrene
cer	= ceramic	pot	= potentiometer
comp	= composition	rect	= rectifier
depc	= deposited carbon	rot	= rotary
elect	= electrolytic	s-b	= slow-blow
f	= farads	Se	= selenium
f-a	= fast acting	sect	= section(s)
fxd	= fixed	Si	= silicon
Ge	= germanium	SPL	= special
incd	= incandescent	Ta	= tantalum
metflm	= metal film	Ti	= titanium dioxide
MFR	= manufacturer	tog	= toggle
my	= mylar	tol	= tolerance
NC	= normally closed	v	= volts
Ne	= neon	var	= variable
NFR	= not field replaceable	w/	= with
NO	= normally open	w	= watts
NPO	= zero temp coeff	ww	= wirewound
NSN	= no stock number	w/o	= without
NSR	= not separately replaceable	*	= optimum value selected, nominal value shown (component may be omitted)
OBD	= order by description		
pc	= printed circuit board		
piv	= peak inverse voltage		

5.4 RECOMMENDED INDUSTRIAL SPARES

In situations where down-time of the equipment is of critical importance, it is recommended that one of each of the following plug-in etched circuit boards or assemblies be stocked. This instrument can then be kept in operation while the faulty board or assembly is being repaired. The items listed without designation or stock number are for page number reference only.

Ref. Des.	Description	Stock No.	Page No.
A1-5	Decade Divider	5212A-65C	5-11
A6	100 KC Oscillator	5212A-65F	5-13
A7	-35V Regulator & Reset Circuit	5060-3830	5-15
A8	Attenuator Coupling Logic	5060-2014	5-18
A9	DY-2410B Units Coupling Logic	5060-2015	5-19
A10	Overload Detector	5060-2181	5-20
A10A1	Voltage Comparator	5060-2012	5-21
A11-15, 46	Reversible Decade Counter	5060-3781	5-23
A16	Reversible Counter Logic	5060-3809	5-25
A17	Gate Control	5060-5002	5-28
A18	Display Control	5060-2052	5-30
A19	Control Logic A	5060-3829	5-32
A20	Control Logic B	5060-2009	5-34
A21	Control Logic C	5060-2010	5-35
A22	Logic Card	5060-2111	5-37
A23	AC Ohms Delay Gate	5060-3771	5-38
A24	Units Display	5060-3818	5-40
A25	Sensitivity Control	5060-2018	5-41
A26	Input Amplifier	5214-6014	5-42
A27	Schmitt Trigger	5060-5016	5-44
A29	+6V Bias Supply	5060-3805	5-47
A30	DY-2411A Decimal Point Logic	5060-2108	5-48
A31	Operational Amplifier	5060-3848	5-49

Ref. Des.	Description	Stock No.	Page No.
A32	Negative Channel	5060-5001	5-54
A33	Positive Channel	5060-3849	5-57
A32A2, A33A2	Binary Printed Circuit	5060-3834	5-60
A34	Series Regulator	5060-3782	5-61
A35	Power Supply Amplifier	5060-3783	5-63
A36	Rectifier Filter Board	5060-3806	5-66
A47	Relay Time Circuit	5060-3691	5-67

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
	<u>Main Chassis</u>					
	Decimal Lamp					
	Voltage-to-Frequency Converter Chassis					
A1-5	Decade Divider	5212A-65C	28480		5	
A6	100 KC Oscillator	5212A-65F	28480		1	
A7	-35V Regulator & Reset Circuit	5060-3830	04404		1	
A8	Attenuator Coupling Logic	5060-2014	04404		1	
A9	DY-2410B Units Coupling Logic	5060-2015	04404		1	
A10	Overload Detector	5060-2181	04404		1	
A10A1	Voltage Comparator					
A11-15, 46	Reversible Decade Counter	5060-3781	04404		6	
A16	Reversible Counter Logic	5060-3809	04404		1	
A17	Gate Control	5060-5002	04404		1	
A18	Display Control	5060-2052	04404		1	
A19	Control Logic A	5060-3829	04404		1	
A20	Control Logic B	5060-2009	04404		1	
A21	Control Logic C	5060-2010	04404		1	

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A22	Logic Card	5060-2111	04404		1	
A23	AC Ohms Delay Gate	5060-3771	04404		1	
A24	Units Display	5060-3818	04404		1	
A25	Sensitivity Control	5060-2018	04404		1	
A26	Input Amplifier	5214-6014	28480		1	
A27	Schmitt Trigger	5060-5016	04404		1	
A28	Programmable DC Attenuator	5060-5115	04404		1	
A29	+6V Bias Supply	5060-3805	04404		1	
A30	2411A Decimal Point Logic	5060-2108	04404		1	
A31	Operational Amplifier	5060-3848	04404		1	
A32	Negative Channel	5060-5001	04404		1	
A33	Positive Channel	5060-3849	04404		1	
A32A2, A33A2	Binary Printed Circuit				2	
A34	Series Regulator	5060-3782	04404		1	
A35	Power Supply Amplifier	5060-3783	04404		1	
A36	Rectifier Filter Board	5060-3806	04404		1	
A47	Relay Time Circuit	5060-3691	04404		1	

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
	Main Chassis					
B101	Fan: 115v	3160-0026	28480		1	1
C1	C: fxd, elect, 20 μf, -10 +75%, 200v	0180-0367	56289	34D206G200FJ4	1	1
C2	C: fxd, elect, 500 μf, 75v	0180-0047	56289	D32443	1	1
C3	C: fxd, mica, 130 pf, 5%, 300v	0140-0195	04062	DM15F131J	1	1
C4	C: var, cer, 7-45 pf, 500v	0130-0001	28480		1	1
C5	C: fxd, mica, 470 μf, 5%, 300v	0140-0149	04062	DM15F471J	1	1
C10	C: fxd, elect, 20 μf, 50v	0180-0049	56289	30D198A1	1	1
C202	C: fxd, my, .22 μf, 10%, 200v	0170-0038	56289	148P22492	1	1
CR2, 3	Diode: Si, 1N1116	1901-0060	04713	1N1116	2	2
F1	Fuse: 2a, 125v	2110-0006	75915	313002	1	10
	Fuseholder for above	1400-0084	75915	342014	1	
FL1	Filter: RFI	9110-0103	56289	JN10-1152B	1	1
J1	Connector: receptacle, 37 pin, female	1251-0119	71468	MS3102A28-21S	1	1
J2	Connector: 50 pin, female	1251-0087	02660	57-40500	1	1
J3, 4, 8, 9	Connector: receptacle, BNC, UG1094A/U	1250-0118	91737	8427	4	2

M0185

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
	Main Chassis - Cont'd					
J31	Connector: input, 3 pin, male	1251-0349	04919	7282	1	1
L1	Choke: 35 mh, 1.5a	9110-0067	98734	12098	1	1
Q1	Transistor: Ge, PNP, 2N1540	1850-0132	04713	2N1540	1	1
Q3	Transistor: Ge, PNP, 2N1183	1850-0064	02735	2N1183	1	1
R1	R: fxd, ww, 10K, 5%, 5w	0813-0007	28480		1	1
R2	R: fxd, comp, 1250Ω, 5%, 10w	0816-0014	28480		1	1
R3	R: fxd, comp, 1K, 5%, 2w	0692-1025	01121	HB1025	1	1
R4	R: fxd, comp, 220K, 5%, 1/4w	0683-2245	01121	CB2245	1	1
R5	R: fxd, comp, 470K, 5%, 1/2w	0686-4745	01121	EB4745	1	1
R6, 7	R: fxd, comp, 1K, 5%, 1/4w	0683-1025	01121	CB1025	2	1
R8	R: fxd, ww, 68K, 5%, 1/4w	0683-6835	01121	CB6835	1	1
R9	R: fxd, comp, 3K, 5%, 1/4w	0683-3025	01121	CB3025	1	1
R202	R: fxd, comp, 11K, 5%, 1/2w	0686-1135	01121	EB1135	1	1
R203	R: fxd, comp, 43K, 5%, 1/2w	0686-4335	01121	EB4335	1	1
R204	R: var, 250K (part of S5)					
S1	Switch: rot, 8 pos, RANGE	3100-1402	28480		1	1
S2	Switch: rot, 12 pole, 3/4 pos, FUNCTION	3100-0711	28480		1	1
S3	Switch: rot, 6 pole, 6 pos, SAMPLE PERIOD	3100-0464	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
	<u>Main Chassis - Cont'd</u>					
S4	Switch: push, SPDT, RESET	3101-0004	28480		1	1
S5	Switch: rot, w/250K pot, SAMPLING RATE	3100-0466	28480		1	1
S6	Switch: tog, DPDT, 100 KC STD	3101-0005	04009	81027-CE	1	1
S7, 10	Switch: tog, SPST, STORE DISPLAY, POWER	3101-0001	04009	80994-H	2	1
S11	Switch: slide, 115/230v, DPDT	3101-0033	88140	8906K366	1	1
T1	Transformer: power	9100-0211	28480		1	1
XA1-8, 10, 17, 18, 32-34	Connector: pc, 15 pin	1251-0135	95354	SD-615UR	14	2
XA9, 31, 35,	Connector: pc, 18 pin	1251-0141	95354	SD-618UR	3	1
XA11-15, 46	Connector: pc, 30 pin	1251-1024	95238	600-120-GD-3XA	6	2
XA16	Connector: pc, 36 pin	1251-1035	95238	600-111-18X	1	1
XA19-22, 32	Connector: pc, 24 pin	1251-0332	95354	SD-624UR	5	1
XA24	Connector: pc, 20 pin	1251-1034	95238	600-120-GD-2X-A	1	1
XA26, 27	Connector: pc, 6 pin	1251-0475	28480		2	1
XA29	Connector: pc, 10 pin	1251-0166	28480		1	1
Y1	Crystal: quartz, 100 KC, 0.005%	0410-0021	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
	Main Chassis - Cont'd					
	Decimal Lamp Assembly	5060-3639	04404			
DS1-5	Lamp: glow, NE-2E	2140-0022	24455	NE-2E	5	2
R1-5	R: fxd, comp, 1M, 5%, 1/4w	0683-1055	01121	CB1055	5	2
R6-10	R: fxd, comp, 82K, 5%, 1/4w	0683-8235	01121	CB8235	5	2
	Voltage-to-Frequency Converter Chassis					
C32	C: fxd, elect, 100 μf, 20v	0180-0098	28480		1	1
C34	C: fxd, Ta, 56 μf, 15v	0180-0196	01295	SCM566GP015D2	1	1
J10, 11, 34	Connector: female	1251-0373	98291	SKT-23	3	1
R33, 35	R: var, ww, 50Ω, 10%, 2w	2100-0963	28480		2	1
R34	R: var, ww, 10K, 10%, 2w	2100-0704	28480		1	1
R48	R: fxd, ww, 100K, 0.01%, 1w	0811-0354	28480		1	1
R49, 50	R: fxd, mtflm, 13.3K, 1%, 1/8w, ±100 ppm /°C	0757-0289	28480		2	1
R61, 62	R: fxd, mtflm, 1.2K, 2%, 1/8w, ±150 ppm /°C	0757-0926	28480		2	1
T2	Transformer: power	9100-1201	28480		1	1
T4, 5	Transformer: pulse, shielded	5080-1439	04404		2	1
XA23	Connector: pc, 15 pin	1251-0135	95354	SD-615UR	1	1

Reference Designation	Description	(hp) Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A1-5	Decade Divider Assembly	5212A-65C	28480			
C1	C: fxd, mica, 110 pf, 300v	0150-0121	14655	CD15F221F-300V	1	1
C2, 11	C: fxd, mica, 110 pf, 300v	0140-0194	14655	CD15F111J-300V	2	1
C3, 4, 9, 10	C: fxd, mica, 130 pf, 300v	0140-0195	14655	CD15F131J-300V	4	2
C5-7	C: fxd, mica, 150 pf, 300v	0140-0196	14655	CD15F151J-300V	3	1
C8	C: fxd, mica, 240 pf, 300v	0140-0199	14655	CD15F241J-300V	1	1
C12, 13	C: fxd, mica, 200 pf, 300v	0140-0198	14655	CD15F201J-300V	2	1
C14	C: fxd, mica, 390 pf, 300v	0140-0200	14655	CD15F391J-300V	1	1
CR1-5	Diode: Ge, HD1409	1910-0015	73293	HD1409	5	5
Q1-8	Transistor: Ge, 2N404	1850-0062	94145	T51602	8	3
R1	R: fxd, comp, 390 μf, 5%, 1/2w	0686-3915	01121	EB3915	1	1
R2, 4, 10, 12, 13, 15, 21, 23, 25, 27, 33, 35, 36, 38, 44, 46	R: fxd, comp, 47K, 5%, 1/2w	0686-4735	01121	EB4735	16	4
R3, 9, 14, 20, 26, 32, 37, 43	R: fxd, comp, 6800Ω, 5%, 1/2w	0686-6825	01121	EB6825	8	3
R5, 11, 22, 28, 39, 45	R: fxd, comp, 10K, 5%, 1/2w	0686-1035	01121	EB1035	6	2

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R6, 8, 17, 19, 29, 31, 40, 42	R: fxd, comp, 3900Ω, 5%, 1/2w	0686-3925	01121	EB3925	8	3
R7, 18, 30, 41	R: fxd, comp, 200Ω, 5%, 1/2w	0686-2015	01121	EB2015	4	2
R16, 34	R: fxd, comp, 8200Ω, 5%, 1/2w	0686-8225	01121	EB8225	2	1
R24	R: fxd, comp, 68K, 5%, 1/2w	0686-6835	01121	EB6835	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A6	100KC Oscillator Assembly	5212A-65F	28480			
C1	C: fxd, mica, .1 μf, 500v, -70 ppm/°C	0150-0121	14655	CB15F221F	1	1
C2	C: fxd, my, 1 μf, 10%, 200v	0170-0072	09134	1042	1	1
C3	C: fxd, mica, 1500 μf, 2%, 300v, -70 ppm /°C	0140-0156	04062	D19F152G	1	1
CR1	Diode: Ge, 60 piv, 5 ma	1910-0011	28480		1	1
Q1	Transistor: Ge, 2N169A	1851-0006	03508	2N169A	1	1
Q2, 3	Transistor: Ge, 2N404	1850-0062	28480		2	1
R2	R: fxd, comp, 68K, 5%, 1/2w	0686-6835	01121	EB6835	1	1
R3, 5	R: fxd, comp, 10K, 5%, 1/2w	0686-1035	01121	EB1035	2	1
R4, 14	R: fxd, comp, 22K, 5%, 1/2w	0686-2235	01121	EB2235	2	1
R6	R: fxd, comp, 1.2K, 5%, 1/2w	0686-1225	01121	EB1225	1	1
R7	R: fxd, comp, 56K, 5%, 1/4w	0683-5635	01121	CB5635	1	1
R8	R: fxd, comp, 1.8K, 5%, 1/4w	0683-1825	01121	CB1825	1	1
R9	R: fxd, comp, 5.6K, 5%, 1/2w	0686-5625	01121	EB5625	1	1
R10	R: fxd, comp, 5.6K, 5%, 1/4w	0683-5625	01121	CB5625	1	1
R11	R: fxd, comp, 2.2K, 5%, 1/4w	0683-2225	01121	CB2225	1	1
R12	R: fxd, comp, 47Ω, 5%, 1/4w	0683-4705	01121	CB4705	1	1

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Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R13	R: fxd, comp, 3.9K, 5%, 1/2w	0686-3925	01121	EB3925	1	1
R15	R: fxd, comp, 1K, 5%, 1/4w	0683-1025	01121	CB1025	1	1
T1	Transformer: oscillator	5212A-9A	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A7	-35V Regulator & Reset Circuit	5060-3830	04404			
C1	C: fxd, my, 0.022 μf, 20%	0170-0024	28480		1	1
C2	C: fxd, Ta, 2.2 μf, 10%, 20v	0180-0197	56289	150D225X9020A2	1	1
C3, 4	C: fxd, cer, 0.005 μf, 500v	0150-0014	04222	D1-4	2	1
C5	C: fxd, cer, 0.1 μf, 20%, 50v	0150-0121	56289	5C50	1	1
CR1	Diode: avalanche, 5.9 to 6.5, 400 mw	1902-0033	28480		1	1
CR2	Diode: avalanche, 10v, 5%, 400 mw	1902-0025	28480		1	1
CR3, 5	Diode: Si	1901-0081	28480		2	2
CR4	Diode: Si, 1N816	1901-0061	03877	1N816	1	1
CR6	Diode: avalanche, 2.4v, 10%, 400 mw	1902-0022	28480		1	1
Q1	Transistor: Ge, PNP, 2N466	1850-0124	04713	2N466	1	1
Q2, 3	Transistor: Ge, PNP, 2N404	1850-0032	02735	2N404	2	1
Q4-6	Transistor: Ge, PNP, 2N404A	1850-0111	01295	2N404A	3	1
Q7	Transistor: Ge, NPN, 2N388A	1851-0024	01295	2N388A	1	1
R1, 2	R: fxd, ww, 0.15Ω, 5%, 2.5w	0812-0045	94310	RW59GR15	2	1
R4, 23	R: fxd, comp, 12K, 5%, 1/4w	0683-1235	01121	CB1235	2	1
R5, 15	R: fxd, comp, 470Ω, 5%, 1/4w	0683-4715	01121	CB4715	2	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R6	R: fxd, comp, 3.6K, 5%, 1/2w	0686-3625	01121	EB3625	1	1
R7	R: fxd, comp, 3.6K, 5%, 1/4w	0683-3625	01121	CB3625	1	1
R8	R: fxd, comp, 6.8K, 5%, 1/4w	0683-6825	01121	CB6825	1	1
R9	R: fxd, cflm, 464Ω, 1%, 1/2w	0727-0739	28480		1	1
R10	R: var, ww, 100Ω, 10%, 1/2w	2100-0490	28480		1	1
R12	R: fxd, cflm, 2.37K, 1%, 1/2w	0727-0764	28480		1	1
R13, 29	R: fxd, comp, 1.2K, 5%, 1/4w	0683-1225	01121	CB1225	2	1
R14	R: fxd, comp, 2K, 5%, 1/2w	0686-2025	01121	EB2025	1	1
R16, 19, 25, 27	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	4	1
R17	R: fxd, comp, 4.7K, 5%, 1/4w	0683-4725	01121	CB4725	1	1
R18	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	1	1
R20	R: fxd, comp, 1K, 5%, 1/4w	0683-1025	01121	CB1025	1	1
R21, 26, 30	R: fxd, comp, 27K, 5%, 1/4w	0683-2735	01121	CB2735	3	1
R22	R: fxd, comp, 15K, 5%, 1/4w	0683-1535	01121	CB1535	1	1
R24	R: fxd, comp, 2.7K, 5%, 1/4w	0683-2725	01121	CB2725	1	1
R28	R: fxd, comp, 2.2K, 5%, 1/4w	0683-2225	01121	CB2225	1	1

Reference Designation	Description	(hp) Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R31	R: fxd, comp, 100Ω, 5%, 1/4w	0683-1015	01121	CB1015	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A8	Attenuator Coupling Logic	5060-2014	04404			
CR1, 2, 4-6	Diode: Si	1901-0025	28480		5	5
CR3, 7-16	Diode: Ge, 100 ma at 0.85v	1910-0016	28480		11	11
Q1, 3, 6-9	Transistor: Ge, PNP, 2N398B	1850-0128	02735	2N398B	6	2
Q2, 4	Transistor: Ge, PNP, 2N1997	1850-0113	01295	2N1997	2	1
Q5	Transistor: Ge, 2N398B	1850-0147	28480		1	1
R1, 5, 11	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	3	1
R2, 14-18	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	6	2
R3, 9	R: fxd, comp, 4.7K, 5%, 1/4w	0683-4725	01121	CB4725	2	1
R4, 7, 10, 13, 20-23	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	8	3
R6, 12	R: fxd, comp, 2.7K, 5%, 1/4w	0683-2725	01121	CB2725	2	1
R8	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	1	1
R19	R: fxd, comp, 4.7K, 5%, 1/2w	0686-4725	01121	EB4725	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A9	DY-2410B Units Coupling Logic	5060-2015	04404			
CR1-3, 5-8, 10-12	Diode: Ge, 100 ma at 0.85v	1910-0016	28480		10	10
CR4, 13	Diode: Si	1901-0025	28480		2	2
Q1-5	Transistor: Ge, PNP, 2N398B	1850-0128	02735	34600	5	2
R1, 9, 16, 17	R: fxd, comp, 330Ω, 5%, 1w	0689-3315	01121	GB3315	4	2
R2, 4, 5, 7, 10, 12, 13	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	7	3
R3, 6, 14	R: fxd, comp, 4.7K, 5%, 1/4w	0683-4725	01121	CB4725	3	1
R8, 11, 15	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	3	1

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Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A10	Overload Detector	5060-2181	04404			
C1	C: fxd, mica, 50.6 pf, 0.5%, 500v	0160-0257	28480		1	1
C6	C: fxd, mica, 220 pf, 5%, 300v	0160-0134	14655	CD15F221J	1	1
C7	C: fxd, mylar, 0.1 μf, 10%	0160-0168	28480		1	1
C8	C: fxd, mylar, 0.033 μf, 10%	0160-0163	28480		1	1
C9, 10	C: fxd, mylar, 0.01 μf, 10%	0160-0161	28480		2	1
CR1, 2	Diode: Si, 1N625	1901-0071	73293	1N625	2	2
CR6	Diode: Si, 38v	1903-0003	98925	4EX179	1	1
CR7	Diode: Si	1901-0025	28480		1	1
CR8	Diode: Ge, 100 ma at 0.85v	1910-0016	28480		1	1
CR9	Diode: avalanche, 2.67v, 10%, 400 mw	1902-0022	28480		1	1
Q2	Transistor: Ge, PNP, 2N383	1850-0040	94154	2N383	1	1
R1	R: fxd, cflm, 1000Ω, 1%, 1/2w	0727-0751	28480		1	1
R2	R: var, ww, 200Ω, 10%, 0.25w	2100-0369	28480		1	1
R3	R: fxd, cflm, 2.87K, 1%, 1/2w	0727-0766	28480		1	1
R4	R: fxd, cflm, 31.6K, 1%, 1/2w	0727-0792	28480		1	1
R10, 12, 16	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	3	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R11	R: fxd, mtflm, 2.7K, 5%, 1/2w	0758-0004	28480		1	1
R13	R: fxd, comp, 10Ω, 5%, 1/4w	0683-1005	01121	CB1005	1	1
R14	R: fxd, comp, 180Ω, 5%, 1w	0689-1815	01121	GB1815	1	1
R15	R: fxd, comp, 22K, 5%, 1/4w	0683-2235	01121	CB2235	1	1
R18	R: fxd, comp, 100Ω, 5%, 1/4w	0683-1015	01121	CB1015	1	1
R19	R: fxd, comp, 6.8K, 5%, 1/4w	0683-6825	01121	CB6825	1	1
A10A1	Voltage Comparator	5060-2012	04404			
C2	C: fxd, mica, 470 μμf, 5%, 300v	0140-0149	04062	DM15F471J	1	1
C3	C: fxd, mylar, 0.15 μf, 10%, 200v	0160-0303	28480		1	1
C4	C: fxd, elect, 40 μf, -15 +100%, 50v	0180-0050	56289	D32538	1	1
C5	C: fxd, mylar, 0.01 μf, 10%	0160-0161	28480		1	1
CR3, 4	Diode: Si, 1N628	1901-0058	03877	1N628	2	2
CR5	Diode: Ge, 1N270	1910-0023	73293	1N270	1	1
L1	Choke: coil, fxd, R.F., 1 mh, 10%	9140-0053	99848	31000-15-102	1	1
Q1	Transistor: Ge, PNP, 2N650	1850-0048	04713	2N650	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R5	R: fxd, cflm, 1M, 1%, 1/2w	0727-0274	28480		1	1
R6	R: fxd, comp, 56K, 5%, 1/4w	0683-5635	01121	CB5635	1	1
R7	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	1	1
R9	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	1	1
T1	Transformer: power	5080-1454	04404		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A11-15, 46	Reversible Decade Counter	5060-3781	04404			
C1, 2, 5, 6, 9, 12	C: fxd, mica, 130 pf, 5%, 300v	0140-0195	04062	DM15F131J	6	2
C3, 4, 7, 8, 10, 11	C: fxd, mica, 180 pf, 2%	0140-0219	28480		6	2
C13-18	C: fxd, mica, 110 pf, 5%, 300v	0140-0194	04062	DM15F111J	6	2
CR1-8	Diode: Si	1901-0025	28480		8	8
CR9-11, 13-24, 26-34	Diode: Si	1901-0081	28480		24	24
DS1-4 DS5	Part of Readout Block Assembly Nixie	NSR 1970-0009			4	
Q1-8	Transistor: Ge, PNP, 2N404A	1850-0184	01295	2N404A	8	3
R1, 5, 9, 13	R: fxd, comp, 390K, 5%, 1/4w	0683-3945	01121	CB3945	4	2
R2, 3, 6, 7, 10, 11, 14, 15	R: fxd, comp, 56K, 5%, 1/4w	0683-5635	01121	CB5635	8	3
R4, 8, 12, 16	R: fxd, comp, 100K, 5%, 1/4w	0683-1045	01121	CB1045	4	2
R17-26, 48, 49, 53, 54, 58, 59, 64, 65	R: fxd, comp, 22K, 5%, 1/4w	0683-2235	01121	CB2235	18	4
R27-30, 32, 33, 36, 37	R: fxd, comp, 5.6K, 5%, 1/2w	0686-5625	01121	EB5625	8	3
R31, 34, 35, 38, 68	R: fxd, comp, 68K, 5%, 1/4w	0683-6835	01121	CB6835	5	2

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R39-46	R: fxd, comp, 27K, 5%, 1/4w	0683-2735	01121	CB2735	8	3
R47, 50, 52, 55, 57, 60, 63, 66	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	8	3
R51, 56, 61, 62, 67	R: fxd, comp, 3K, 5%, 1/4w	0683-3025	01121	CB3025	5	2
R69	R: fxd, comp, 47K, 5%, 1/2w	0686-4735	01121	EB4735	1	1
V1	~~Tube: electron~~ Photoconductor Plate. (Part of Readout Block Assembly)	NSR			1	1
	Readout Block Assembly, hp 05212-6011	NSR			1	

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A16	Reversible Counter Logic	5060-3809	04404			
C2, 4	C: fxd, mica, 220 pf, 5%, 300v	0160-0134	14655	CD15F221J	2	1
C5-9, 11, 18	C: fxd, mica, 110 pf, 5%, 300v	0140-0194	04062	DM15F111J	7	3
C10, 19	C: fxd, mica, 1000 pf, 5%	0160-0938	28480		2	1
C12, 14	C: fxd, mica, 130 pf, 5%, 300v	0140-0195	04062	DM15F131J	2	1
C13	C: fxd, mica, 27 pf, 5%, 500v	0160-0378	72136	DM15E270J	1	1
C15, 16	C: fxd, mica, 160 pf, 2%, 300v	0140-0218	28480		2	1
CR1-37	Diode: Si	1901-0081	28480		37	37
CR38, 39	Diode: Si	1901-0143	01295	T.I. 254	2	2
Q1, 2, 17-19, 25	Transistor: Si, PNP, 2N3250	1853-0008	04713	2N3250	6	2
Q3-10, 15, 16, 22-24	Transistor: Ge, PNP, 2N404A	1850-0111	01295	2N404A	13	3
Q11-14, 15	Transistor: Si, NPN, 2N3053	1854-0039	02735	2N3053	5	2
R1, 32, 33, 36, 47, 51, 78, 79	R: fxd, comp, 16K, 5%, 1/4w	0683-1635	Q1121	CB1635	8	3
R2, 52	R: fxd, comp, 1K, 5%, 1/4w	0683-1025	01121	CB1025	2	1
R3, 19, 21, 53, 82	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	5	2

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Reference Designation	Description	(hp) Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R4, 8, 29, 75, 84	R: fxd, comp, 22K, 5%, 1/4w	0683-2235	01121	CB2235	5	2
R5, 7	R: fxd, comp, 7.5K, 5%, 1/2w	0686-7525	01121	EB7525	2	1
R6, 9, 56, 68	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	4	2
R10-12, 14, 15, 26, 31, 37, 40, 48	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	10	3
R13, 30, 38	R: fxd, comp, 11K, 5%, 1/4w	0683-1135	01121	CB1135	3	1
R16, 23, 39, 43, 45, 80	R: fxd, comp, 12K, 5%, 1/4w	0683-1235	01121	CB1235	6	2
R17, 18, 24, 77	R: fxd, mtflm, 6.2K, 2%, 1/4w	0757-0943	28480		4	2
R20, 22	R: fxd, comp, 330Ω, 5%, 1w	0689-3315	01121	GB3315	2	1
R25, 41, 50	R: fxd, comp, 5.6K, 5%, 1/2w	0686-5625	01121	EB5625	3	1
R27, 28	R: fxd, comp, 3.9K, 5%, 1/2w	0686-3925	01121	EB3925	2	1
R34, 67, 76	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	3	1
R35	R: fxd, comp, 6.8K, 5%, 1/4w	0683-6825	01121	CB6825	1	1
R42, 49	R: fxd, comp, 5.6K, 5%, 1/4w	0683-5625	01121	CB5625	2	1
R44, 46	R: fxd, comp, 33Ω, 5%, 1/4w	0683-3305	01121	CB3305	2	1
R54, 81	R: fxd, comp, 15K, 5%, 1/4w	0683-1535	01121	CB1535	2	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R55, 69, 72, 85	R: fxd, comp, 4.7K, 5%, 1/4w	0683-4725	01121	CB4725	4	2
R57	R: fxd, comp, 4.7K, 5%, 1/2w	0686-4725	01121	EB4725	1	1
R58, 61, 73	R: fxd, comp, 43K, 5%, 1/4w	0683-4335	01121	CB4335	3	1
R60	R: fxd, comp, 3.3K, 5%, 1/2w	0686-3325	01121	EB3325	1	1
R63, 64	R: fxd, mtflm, 18K, 2%, 1/8w, ±150 ppm/°C	0757-0954	28480		2	1
R65	R: fxd, mtflm, 2K, 2%, 1/4w	0757-0931	28480		1	1
R66	R: fxd, mtflm, 15K, 2%, 1/4w	0757-0952	28480		1	1
R70	R: fxd, comp, 2.2K, 5%, 1w	0689-2225	01121	GB2225	1	1
R71	R: fxd, comp, 100Ω, 5%, 1/4w	0683-1015	01121	CB1015	1	1
R74	R: fxd, comp, 2.7K, 5%, 1w	0689-2725	01121	GB2725	1	1
R83	R: fxd, comp, 4.3K, 5%, 1/4w	0683-4325	01121	CB4325	1	1
R86	R: var, ww, 200Ω, 10%, .25w	2100-0815	28480		1	1

Reference Designation	Description	ⓗⓟ Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A17	Gate Control	5060-5002	04404			
C1, 2	C: fxd, mica, 110 pf, 5%	0140-0194	28480		2	1
C3, 4	C: fxd, mica, 390 pf, 5%, 300v	0140-0200	04062	DM15F391J	2	1
C5	C: fxd, cer, 0.1 μf, 20%, 50v	0150-0121	56289	5C50	1	1
C6	C: fxd, mica, 200 pf, 5%	0140-0198	28480		1	1
C7	C: fxd, cer, .01 μf, +80 -20%, 100v	0150-0093	91418	TA	1	1
CR1-3, 6, 7, 9	Diode: Si	1901-0081	28480		6	6
CR4, 5	Diode: Si, 1N816	1901-0061	03877	1N816	2	1
CR8	Diode: Si, 4.6 to 5.1v at 5 ma, 250 mw	1902-0094	73293	1N705A	1	1
Q1, 2, 4	Transistor: Ge, PNP, 2N404A	1850-0111	01295	2N404A	3	1
Q3, 7, 8	Transistor: Si, NPN	1854-0003	28480		3	1
Q5, 6	Transistor: Ge, NPN, 2N388A	1851-0024	01295	2N388A	2	1
R1, 2, 4, 28	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	4	2
R3	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	1	1
R5, 13	R: fxd, mtflm, 2.7K, 1w	0761-0027	28480		2	1
R6, 14	R: fxd, mtflm, 22K, 5%, 1/4w	0683-2235	01121	CB2235	2	1
R7, 15	R: fxd, comp, 4.7K, 5%, 1/4w	0683-4725	01121	CB4725	2	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R8	R: fxd, comp, 24K, 5%, 1/4w	0683-2435	01121	CB2435	1	1
R9	R: fxd, comp, 27Ω, 5%, 1/4w	0683-2705	01121	CB2705	1	1
R10	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	1	1
R11, 25, 27	R: fxd, comp, 68K, 5%, 1/4w	0683-6835	01121	CB6835	3	1
R12, 20	R: fxd, comp, 1K, 5%, 1/4w	0683-1025	01121	CB1025	2	1
R16, 24	R: fxd, comp, 27K, 5%, 1/4w	0683-2735	01121	CB2735	2	1
R17	R: fxd, comp, 2.2K, 5%, 1/4w	0683-2225	01121	CB2225	1	1
R18, 21	R: fxd, comp, 3.9K, 5%, 1/2w	0686-3925	01121	EB3925	2	1
R19, 22	R: fxd, comp, 47Ω, 5%, 1/4w	0683-4705	01121	CB4705	2	1
R23, 26	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	2	1
R29	R: fxd, comp, 100K, 5%, 1/4w	0683-1045	01121	CB1045	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
<u>A18</u>	<u>Display Control</u>	5060-2052	04404			
C1	C: fxd, mica, 470 pf, 5%, 300v, -70 ppm/°C	0140-0149	04062	DM15F471J	1	1
C2	C: fxd, cer, 1.0 μf, 20%, 25v	0160-0127	56289	5C13	1	1
C3	C: fxd, Ta, 6.8 μf, 10%, 35v	0180-0116	56289	150D685X9035B2	1	1
C4, 5	C: fxd, mica, 390 pf, 5%, 300v, +70 ppm/°C	0140-0200	04062	DM15F391J	2	1
C6, 9	C: fxd, cer, .005 μf, 5%, 500v	0150-0014	04222	D1-4	2	1
C7	C: fxd, mica, 1000 pf, 5%, 300v, -70 ppm/°C	0140-0152	04062	DM16F102J	1	1
C8	C: fxd, elect, 50 μf, -10 +100%, 25v	0180-0058	56289	D28110	1	1
C10	C: fxd, elect, 20 μf, 50v	0180-0049	56289	30D198A1	1	1
C11	C: fxd, my, 0.0033 μf, 10%	0160-0155	28480		1	1
CR1	Diode: Si	OBD	28480		1	1
CR2, 8, 9	Diode: Si	1901-0025	28480		3	3
CR3-6	Diode: Ge, 60 piv, 5 ma	1910-0011	28480		4	4
CR7	Diode: Si, 15v breakdown	OBD	28480		1	1
Q1, 3, 6	Transistor: Ge, PNP, 2N383	1850-0040	94154	2N383	3	1
Q2, 4, 5	Transistor: Ge, PNP, 2N404	1850-0062	28480		3	1
Q7	Transistor: Ge, NPN, 2N388A	1851-0024	01295	2N388A	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R1, 6, 11	R: fxd, comp, 5.6K, 5%, 1/2w	0686-5625	01121	EB5625	3	1
R2, 3, 4, 12	R: fxd, comp, 3.3K, 5%, 1/4w	0683-3325	01121	CB3325	4	2
R5	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	1	1
R7, 9	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	2	1
R8	R: fxd, comp, 6.8K, 5%, 1/2w	0686-6825	01121	EB6825	1	1
R10, 17	R: fxd, comp, 27K, 5%, 1/4w	0683-2735	01121	CB2735	2	1
R13	R: fxd, comp, 15K, 5%, 1/4w	0683-1535	01121	CB1535	1	1
R14	R: fxd, comp, 24K, 5%, 1/4w	0683-2435	01121	CB2435	1	1
R15	R: fxd, comp, 390Ω, 5%, 1/4w	0683-3915	01121	CB3915	1	1
R16, 19	R: fxd, comp, 2.2K, 5%, 1/4w	0683-2225	01121	CB2225	2	1
R18	R: fxd, comp, 2.7K, 5%, 1/4w	0683-2725	01121	CB2725	1	1
R20	R: fxd, comp, 1.2K, 5%, 1/4w	0683-1225	01121	CB1225	1	1
R21	R: fxd, comp, 1K, 5%, 1/2w	0686-1025	01121	EB1025	1	1
R22	R: fxd, comp, 68K, 5%, 1/4w	0683-6835	01121	CB6835	1	1
R23	R: fxd, comp, 4.7K, 5%, 1/4w	0683-4725	01121	CB4725	1	1
R24	R: fxd, comp, 5.6K, 5%, 1/4w	0683-5625	01121	CB5625	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A19	Control Logic A	5060-3829	04404			
CR1, 2	Diode: Si, 1N816	1901-0061	03877	1N816	2	2
CR3, 7-18, 20, 21	Diode: Ge, 100 ma at 0.85v	1910-0016	28480		15	15
CR4	Diode: Ge, 1N270	1910-0023	73293	1N270	1	1
CR5, 6, 19	Diode: Si	1901-0081	73293	HD4698	3	1
Q1-7, 9	Transistor: Ge, PNP, 2N398B	1850-0128	02735	2N398B	8	3
Q8, 10-12	Transistor: Ge, PNP, 2N1997	1850-0113	01295	2N1997	4	2
R1	R: fxd, mtflm, 340Ω, 1%, 1/4w	0757-0336	28480		1	1
R2, 3, 40, 41	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	4	2
R4, 8, 25, 29, 31	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	5	2
R5	R: fxd, comp, 22K, 5%, 1/4w	0683-2235	01121	CB2235	1	1
R6, 16	R: fxd, comp, 15K, 5%, 1/4w	0683-1535	01121	CB1535	2	1
R7	R: fxd, comp, 3.3K, 5%, 1/4w	0683-3325	01121	CB3325	1	1
R9, 12, 22	R: fxd, comp, 16K, 5%, 1/4w	0683-1635	01121	CB1635	3	1
R10, 13, 17	R: fxd, comp, 12K, 5%, 1/4w	0683-1235	01121	CB1235	3	1
R11, 14, 18, 24	R: fxd, comp, 3K, 5%, 1/4w	0683-3025	01121	CB3025	4	2

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R15	R: fxd, comp, 27K, 5%, 1/4w	0683-2735	01121	CB2735	1	1
R19, 36, 37, 39	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	4	2
R20, 23, 26, 30, 34	R: fxd, comp, 10K, 5%, 1/4w	0689-1035	01121	CB1035	5	2
R21, 33, 35	R: fxd, comp, 330Ω, 5%, 1w	0689-3315	01121	GB3315	3	1
R27	R: fxd, comp, 8.2K, 5%, 1/4w	0683-8225	01121	CB8225	1	1
R28, 32	R: fxd, comp, 2.7K, 5%, 1/4w	0683-2725	01121	CB2725	2	1
R38	R: fxd, comp, 470Ω, 5%, 1/4w	0683-4715	01121	CB4715	1	1

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Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A20	Control Logic B	5060-2009	04404			
CR1-5, 24-28	Diode: Si	1901-0025	28480		10	10
CR6-23, 29-44	Diode: Ge, 100 ma at 0.85v	1910-0016	28480		34	34
Q1-14	Transistor: Ge, PNP, 2N398B	1850-0128	02735	34600	14	3
R1-5, 9, 11, 12, 14, 15, 20, 24, 27	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	13	3
R6, 8	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	2	1
R10	R: fxd, comp, 100K, 5%, 1/4w	0683-1045	01121	CB1045	1	1
R13, 16-19, 21-23, 25, 26, 29	R: fxd, comp, 43K, 5%, 1/4w	0683-4335	01121	CB4335	11	3
R28	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A21	Control Logic C	5060-2010	04404			
CR1-4, 13-15	Diode: Ge, 100 ma at 0.85v	1910-0016	28480		7	7
CR6-8, 10	Diode: Si	1901-0025	28480		4	4
CR16	Diode: Si	1901-0081	28480		1	1
L1, 2	Coil: fxd, R.F., 27 mh, 10%	9140-0107	99800	1840-38	2	1
Q1-4	Transistor: Ge, PNP, 2N398B	1850-0128	02735	2N398B	4	2
Q5, 7-9	Transistor: Ge, PNP, 2N1997	1850-0113	01295	2N1997	4	2
R1, 5	R: fxd, comp, 15K, 5%, 1/4w	0683-1535	01121	CB1535	2	1
R2, 7	R: fxd, comp, 16K, 5%, 1/4w	0683-1635	01121	CB1635	2	1
R3, 6, 11	R: fxd, comp, 3K, 5%, 1/4w	0683-3025	01121	CB3025	3	1
R4, 15, 17	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	3	1
R8	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	1	1
R9	R: fxd, comp, 12K, 5%, 1/4w	0683-1235	01121	CB1235	1	1
R10	R: fxd, comp, 13K, 5%, 1/4w	0683-1335	01121	CB1335	1	1
R12	R: fxd, comp, 330Ω, 5%, 1w	0689-3315	01121	GB3315	1	1
R13, 14	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	2	1
R16	R: fxd, comp, 2.7K, 5%, 1/4w	0683-2725	01121	CB2725	1	1

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Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R20, 21, 23	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	3	1
R22, 24, 25	R: fxd, comp, 100K, 5%, 1/4w	0683-1045	01121	CB1045	3	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
<u>A22</u>	<u>Logic Card</u>	5060-2111	04404			
CR1, 3-6, 8-12, 14, 16, 18, 19, 21-35, 38, 39, 42-44	Diode: Si	1901-0025	28480		34	34
CR2, 7, 13, 15, 20, 36, 37, 40, 41	Diode: Ge, 100 ma at 0.85v	1910-0016	28480		9	9
Q1-9	Transistor: Ge, PNP, 2N398B	1850-0128	02735	2N398B	9	3
R1, 5, 9, 12, 15, 18, 22-30, 39	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	16	4
R2, 7, 10, 16, 21, 31, 32	R: fxd, comp, 100K, 5%, 1/4w	0683-1045	01121	CB1045	7	3
R3, 4, 6, 8, 13, 14, 19, 20	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	8	3
R11, 17	R: fxd, comp, 4.7K, 5%, 1/4w	0683-4725	01121	CB4725	2	1

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Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A23	AC Ohms Delay Gate	5060-3771	04404			
C1	C: fxd, Ta, 56 μf, 10%, 15v	0180-0196	01295	SCM566GP015D2	1	1
C2, 6, 7	C: fxd, mica, 110 pf, 5%, 300v	0140-0194	84171	DM15F111J	3	1
C3, 5	C: fxd, mica, 390 pf, 5%, 300v	0140-0200	84171	DM15F391J	2	1
C4	C: fxd, cer, .1 μf, 20%, 50v	0150-0121	56289	5C50	1	1
C8	C: fxd, Ta, 1 μf, 10%, 35v	0180-0291	56289	150D105X9035A2	1	1
CR1-8	Diode: Ge, 1N292	1910-0016	73293	1N292	8	8
CR9	Diode: Si, 1N816	1901-0061	03877	1N816	1	1
CR10	Diode: Si	1901-0081	73293	HD4698	1	1
Q1	Transistor: Ge, 2N388A	1851-0024	01295	2N388A	1	1
Q2, 3, 6	Transistor: Ge, 2N404A	1850-0111	93332	2N404A	3	1
Q4, 7	Transistor: Ge, 2N1997	1850-0113	01295	2N1997	2	1
Q5	Transistor: Ge, 2N169A	1851-0006	33173	2N169A	1	1
R1, 6	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	2	1
R2, 9, 19	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	3	1
R3	R: fxd, comp, 51K, 5%, 1/2w	0686-5135	01121	EB5135	1	1
R4, 5	R: fxd, comp, 10Ω, 5%, 1/4w	0683-1005	01121	CB1005	2	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R7	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	1	1
R8, 10, 17, 20, 25	R: fxd, comp, 4.7K, 5%, 1/4w	0683-4725	01121	CB4725	5	2
R11, 16, 21	R: fxd, comp, 22K, 5%, 1/4w	0683-2235	01121	CB2235	3	1
R12, 15	R: fxd, mtflm, 2700Ω, 5%, 1w	0761-0027	07115	C32	2	1
R13	*	NSN			1	
R14, 26	R: fxd, comp, 27Ω, 5%, 1/4w	0683-2705	01121	CB2705	2	1
R18	R: fxd, comp, 27K, 5%, 1/4w	0683-2735	01121	CB2735	1	1
R22, 23	R: fxd, comp, 5.6K, 5%, 1/4w	0683-5625	01121	CB5625	2	1
R24	R: fxd, comp, 8.2K, 5%, 1/4w	0683-8225	01121	CB8225	1	1

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Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A24	Units Display	5060-3818	04404			
DS1-12	Lamp: incandescent	2140-0037	24455	1762	12	3

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A25	Sensitivity Control	5060-2018	04404			
C1	C: fxd, mica, 390 pf, 5%, 300v	0140-0200	84171	DM15F391J	1	1
C2	C: fxd, my, .22 μf, 10%, 400v	0160-0018	56289	160O22494	1	1
R1	R: var, comp, 3M, 20%, 1/4w w/DPST switch	2100-0273	11237	Series VF-45	1	1
R2, 3	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	2	1
S8	Switch: DPST (part of R1)					

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A26	Input Amplifier	5214-6014	28480			
C1	C: fxd, elect, 100 μf, 12v	0180-0039	56289	30D154A1	1	1
C2	C: fxd, mica, 200 pf, 5%, 300v, -70 ppm /°C	0140-0198	28480		1	1
C3	C: fxd, elect, 500 μf, -10 +100%, 3v	0180-0063	56289	30D120A1	1	1
C4	C: fxd, mica, .001 μf, 5%, 300v, -70 ppm /°C	0140-0152	04062	DM16F102J-300V	1	1
C5	C: fxd, elect, 40 μf, -15 +100%, 50v	0180-0050	56289	D32538	1	1
CR1	Diode: avalanche, 8.66v, 5%, 400 mw	1902-0199	28480		1	1
L1	Coil: 35 μh, 10%	9140-0027	28480		1	1
Q1	Transistor: Si	1854-0003	07263	S-3056	1	1
Q2, 3	Transistor: Ge, 2N274	1850-0037	02735	2N274	2	1
R1	R: fxd, comp, 68K, 5%, 1/4w	0683-6835	01121	CB6835	1	1
R2	R: fxd, comp, 180K, 5%, 1/4w	0683-1845	01121	CB1845	1	1
R3	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	1	1
R4	R: fxd, comp, 150K, 5%, 1/4w	0683-1545	01121	CB1545	1	1
R5	R: fxd, comp, 22K, 5%, 1/4w	0683-2235	01121	CB2235	1	1
R6	R: fxd, comp, 39K, 5%, 1/4w	0683-3935	01121	CB3935	1	1

Reference Designation	Description	Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R7	R: fxd, comp, 2.7K, 5%, 1/4w	0683-2725	01121	CB2725	1	1
R8	R: fxd, comp, 6.2K, 5%, 1/2w	0686-6225	01121	EB6225	1	1
R9	R: fxd, comp, 680Ω, 5%, 1/4w	0683-6815	01121	CB6815	1	1
R10	R: fxd, comp, 150Ω, 5%, 1/4w	0683-1515	01121	CB1515	1	1
R11	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	1	1
R12	R: fxd, comp, 1K, 5%, 1/4w	0683-1025	01121	CB1025	1	1
R13	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A27	Schmitt Trigger	5060-5016	04404			
C1	C: fxd, elect, 50 μf, -10 +100%, 25v	0180-0058	56289	D28110	1	1
C2	C: fxd, mica, 240 pf, 5%	0140-0199	28480		1	1
C3	C: fxd, mica, 1500 pf, 2%	0140-0156	28480		1	1
C4	C: fxd, cer, 0.1 μf, 20%, 50v	0150-0121	56289	5C50	1	1
CR1, 2	Diode: Ge, 100 ma at 0.85v	1910-0016	28480		2	2
Q1, 2	Transistor: Ge, PNP, 2N404A	1850-0111	01295	2N404A	2	1
R1	R: fxd, comp, 47K, 5%, 1/4w	0683-4735	01121	CB4735	1	1
R2	R: fxd, comp, 820Ω, 5%, 1/4w	0683-8215	01121	CB8215	1	1
R3	R: var, 1K, 30%, .15w	2100-0154	28480		1	1
R4	R: fxd, comp, 5.6K, 5%, 1/2w	0686-5625	01121	EB5625	1	1
R5	R: fxd, comp, 5.6K, 5%, 1/4w	0683-5625	01121	CB5625	1	1
R6	R: fxd, comp, 2.2K, 5%, 1/4w	0683-2225	01121	CB2225	1	1
R7	R: fxd, mtflm, 2.4K, 1w	0758-0111	28480		1	1
R9	R: fxd, comp, 22K, 5%, 1/4w	0683-2235	01121	CB2235	1	1
R10	R: fxd, comp, 27Ω, 5%, 1/4w	0683-2705	01121	CB2705	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A28	Programmable DC Attenuator	5060-5115	04404			
C101	C: fxd, Ta, 0.82 μf, 10%, 35v	0180-0349	56289	150D824X9035A2	1	1
C102	C: fxd, Ta, 1.5 μf, 10%, 35v	0180-0347	56289	150D155X9035A2	1	1
CR101, 103-105	Diode: Si	1901-0025	28480		4	4
K1-5	Relay: coil	0490-0099	04404		5	1
	Relay contacts for: K1, 2, 4(2), 5	0490-0137	98393	DRS-5	4	2
	K3, 4(1)	0490-0094	95348	MR-600-1	2	1
L10	Choke: 200 μh, 5%	9140-0237	99800	1537-90	1	1
R36, 37	R: fxd, ww, 4.495M, .05% pr, 2 ppm/°C	0811-1516	28480		1pr	1pr
R38	R: fxd, ww, 90K, .01%, 1/2w, 10 ppm/°C	0811-0152	71471	Type CE526	1	1
R39	R: fxd, ww, 900K, .01%, 1w, 5 ppm/°C	0811-0201	71471	Type CE527	1	1
R40	R: var, ww, 20K, 10%, 1/4w	2100-0708	56289	112-203	1	1
R42	R: fxd, ww, 10,080Ω, .1%, 1/2w, 2.5 ppm /°C	0811-0154	71471	Type CE526	1	1
R43	R: var, mtflm, 50Ω, 10%, 400 ppm/°C	2100-1454	28480		1	1
R44	R: fxd, ww, 111K, .05%, 1/2w, 2.5 ppm/°C	0811-0150	71471	Type CE526	1	1
R45	R: var, mtflm, 300Ω, 10%	2100-1455	28480		1	1
R46	R: fxd, ww, 899K, 1/20%, 1w, +2.5 ppm/°C	0811-0355	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R47	R: var, mtflm, 2K, 10%	2100-1456	28480		1	1
R101, 105-107	R: fxd, comp, 390Ω, 5%, 1w	0689-3915	01121	GB3915	4	2
R102	R: fxd, comp, 470Ω, 5%, 1w	0689-4715	01121	GB4715	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A29	+6 Volt Bias Supply	5060-3805	04404			
C1	C: fxd, elect, 150 μf, 30v	0180-0363	56289	34D157H030FJ4	1	1
C2	C: fxd, Ta, 100 μf, 10v	0180-0137	28480		1	1
C3	C: fxd, elect, 20 μf, 200v	0180-0367	56289	34D206G200FJ4	1	1
CR1, 2	Diode: Si	1901-0026	28480		2	2
CR3	Diode: avalanche, 6.34v, 2%	1902-3117	28480		1	1
CR4, 5	Diode: Si	1901-0029	28480		2	2
Q1	Transistor: 2N3053	1854-0039	28480		1	1
R1	R: fxd, comp, 5.6Ω, 5%, 1/4w	0683-0565	01121	CB56G5	1	1
R2	R: fxd, mtflm, 1.47K, 1%, 1/2w	0757-1078	28480		1	1
R3	R: fxd, comp, 470K, 5%, 1/4w	0683-4745	01121	CB4745	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A30	2411A Decimal Point Logic	5060-2108				
CR1-15	Diode: Ge, HD1445	1910-0016	73293		15	15
Q1-13	Transistor: Ge, 2N398B	1850-0128	72699		13	5
R1	R: fxd, comp, 22K, 5%, 1/4w	0683-2235	01121	CB2235	1	1
R2	R: fxd, comp, 24K, 5%, 1/4w	0683-2435	01121	CB2435	1	1
R3, 12	R: fxd, comp, 3.6K, 5%, 1/4w	0683-3625	01121	CB3625	2	1
R4, 8, 11	R: fxd, comp, 18K, 5%, 1/4w	0683-1835	01121	CB1835	3	1
R5	R: fxd, comp, 12K, 5%, 1/4w	0683-1235	01121	CB1235	1	1
R6	R: fxd, comp, 3K, 5%, 1/4w	0683-3025	01121	CB3025	1	1
R7	R: fxd, comp, 20K, 5%, 1/4w	0683-2035	01121	CB2035	1	1
R9	R: fxd, comp, 10K, 5%, 1/4w	0683-1035	01121	CB1035	1	1
R10	R: fxd, comp, 2.7K, 5%, 1/4w	0683-2725	01121	CB2725	1	1
R13, 15, 17-19, 21, 22, 24, 25	R: fxd, comp, 68K, 5%, 1/4w	0683-6835	01121	CB6835	9	3
R14, 16, 20, 23	R: fxd, comp, 33K, 5%, 1/4w	0683-3335	01121	CB3335	4	1

Reference Designation	Description	(hp) Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A31	Operational Amplifier	5060-3848	04404			
C2	C: fxd, Ti, .47 pf, 5%, 500v	0150-0021	78488	Type GA	1	1
C3	C: fxd, poly, 0.027 μf, 20%, 30v	0160-0961	56289	114P2730R3S4	1	1
C4	C: fxd, mica, 1500 pf, 2%	0140-0156	28480		1	1
C5	C: fxd, Ta, 20 μf, 10v	0180-0193	21520	SP-105-21	1	1
C6	C: fxd, Ta, 56 μf, 15v	0180-0196	01295	SCM566GP015D2	1	1
C7	C: fxd, Ta, 3.3 μf, 15v	0180-0210	82376	TES3.3M-15	1	1
C8	C: fxd, Ta, 22 μf, 10%, 15v	0180-0365	56289	150D226X9015B2	1	1
C9	C: fxd, my, 0.47 μf, 10%, 80v	0160-0970	28480		1	1
C10	C: fxd, my, .027 μf, 10%	0170-0066	28480		1	1
C11	C: fxd, Ta, 220 μf, 10v	0180-0159	56289	150D227X0010S2	1	1
C12, 23	C: fxd, mica, 27 pf, 5%, 500v	0160-0378	72136	DM15E270J	2	1
C13, 14	C: fxd, Ta, 100 μf, 20%, 10v	0180-0137	56289	150D107X0010R2	2	1
C15, 18, 24	C: fxd, cer, 0.1 μf, 20%, 50v	0150-0121	56289	5C50	3	1
C16	C: fxd, Ta, 2.2 μf, 20v	0180-0197	56289	150D225X9020A2	1	1
C17	C: fxd, my, .039 μf, 10%	0160-0164	28480		1	1
C19	C: fxd, mica, 22 pf, 5%, 500v	0140-0145	04062	DM15C220J	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
C20, 21	C: fxd, mica, 110 pf, 5%	0140-0194	28480		2	1
C22	C: fxd, poly, 0.27 μf, 20%, 30v	0160-0960	56289	114P2740R3S4	1	1
C25	C: fxd, porcelain, 110 pf, 5%, 500v	0160-0268	95275	VY13C111J-A	1	1
C27	C: fxd, my, .018 μf, 10%, 200v	0160-0302	28480		1	1
CR1-4, 8, 9	Diode: Si	1901-0156	28480		6	6
CR5-7, 12-15	Diode: Si	1901-0025	28480		7	7
CR10, 11	Diode: avalanche, 6.2v	1902-0096	28480		2	2
CR16, 17	Diode: avalanche	1902-0770	28480		2	2
L1	Coil: fxd, R.F., 15 μh, 10%	9140-0082	95265	NA-15.0-I	1	1
L2	Coil: R.F., 42 μh, 10%	9140-0040	99848	1042-15-420	1	1
P1, 29, 30	Terminal: probe	0360-0462	98291	FTM14	3	1
Q1, 5-9	Transistor: Si, NPN	1854-0025	28480		6	2
Q2, 3, 12, 14	Transistor: Si, NPN	1854-0003	28480		4	2
Q4, 10, 11	Transistor: Si, PNP, 2N3250	1853-0008	04713	2N3250	3	1
Q13	Transistor: Si, PNP	1853-0001	28480		1	1
R1, 2, 4	R: fxd, mtflm, 221K, 1%, 1/4w	0757-0783	28480		3	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R3	R: fxd, cflm, 287K, 1%, 1/2w	0727-0819	28480		1	1
R5	R: fxd, mtflm, 1.5M, 1%, 1/2w	0757-0156	28480		1	1
R6, 43	R: fxd, mtflm, 392Ω, 1%, 1/8w	0757-0413	28480		2	1
R7	R: fxd, mtflm, 1.00M, 1%, 1/4w	0757-0344	28480		1	1
R8, 53	R: fxd, mtflm, 1.21K, 1%, 1/8w	0757-0274	28480		2	1
R9	R: fxd, mtflm, 562K, 1%, 1/8w	0757-0483	28480		1	1
R10, 27	R: fxd, mtflm, 475K, 1%, 1/8w	0757-0481	28480		2	1
R11	R: fxd, mtflm, 825Ω, 1%, 1/8w	0757-0421	28480		1	1
R12	R: fxd, mtflm, 56.2K, 1%, 1/8w	0757-0459	28480		1	1
R13	R: fxd, mtflm, 261Ω, 1%, 1/8w	0698-3132	28480		1	1
R14	R: fxd, mtflm, 1.78K, 1%, 1/8w	0757-0278	28480		1	1
R15	R: fxd, mtflm, 182K, 1%, 1/8w	0757-0471	28480		1	1
R16, 20, 22	R: fxd, mtflm, 8.25K, 1%, 1/8w	0757-0441	28480		3	1
R18, 23	R: fxd, mtflm, 100K, 1%, 1/8w	0757-0465	28480		2	1
R19	R: fxd, mtflm, 392K, 1%, 1/8w	0757-0479	28480		1	1
R26	R: fxd, cflm, 4.64M, 1%, 1/2w	0727-0862	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R28, 29, 55	R: fxd, mtflm, 499K, 1%, 1/4w	0757-0327	28480		3	1
R30	R: fxd, mtflm, 27.4K, 1%, 1/8w	0757-0452	28480		1	1
R31, 32, 36, 38, 54	R: fxd, mtflm, 1.00K, 1%, 1/8w	0757-0280	28480		5	2
R33	R: fxd, mtflm, 51.1K, 1%, 1/8w	0757-0458	28480		1	1
R34, 41	R: fxd, mtflm, 1.96K, 1%, 1/8w	0698-0083	28480		2	1
R35	R: fxd, mtflm, 121Ω, 1%, 1/8w	0757-0403	28480		1	1
R37, 44	R: fxd, mtflm, 10.0K, 1%, 1/8w	0757-0442	28480		2	1
R39	R: fxd, mtflm, 17.8K, 1%, 1/8w	0698-3136	28480		1	1
R40	R: fxd, mtflm, 21.5K, 1%, 1/8w	0757-0199	28480		1	1
R42	R: fxd, mtflm, 2.15K, 1%, 1/8w	0698-0084	28480		1	1
R45	R: fxd, mtflm, 3.32K, 1%, 1/4w	0757-0743	28480		1	1
R46	R: fxd, mtflm, 464Ω, 1%, 1/8w	0698-0082	28480		1	1
R47, 50	R: fxd, mtflm, 100Ω, 1%, 1/2w	0757-0198	28480		2	1
R48, 49	R: fxd, mtflm, 22.1Ω, 1%, 1/2w	0757-0992	28480		2	1
R51	R: fxd, mtflm, 14.7K, 1%, 1/8w	0698-3156	28480		1	1
R52	R: fxd, mtflm, 27.4Ω, 1%, 1/8w	0757-0387	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R56	R: fxd, mtflm, 562Ω, 1%, 1/8w	0757-0417	28480		1	1
W1, 2	Jumper: insulated	8159-0005	82142		2	

Reference Designation	Description	(hp) Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A32	Negative Channel	5060-5001	04404		1	
A32A1	Amplifier Board	OBD	04404		1	1
A32A2**	Binary Printed Circuit Board	5060-3838	04404		1	1
R1*	R: fxd, mtflm, 0-47.5K, 1/4w, factory selected	NSR	28480			
R2*	R: fxd, mtflm, 805-953K, 1/4w, factory selected	NSR	28480			
T1	Transformer: pulse, negative	NSR	04404			
A32A1	Amplifier Board Assembly					
C3	C: fxd, mica, 100 pf, 2%, 300v	0140-0176	28480		1	1
C4	C: fxd, my, 0.0056 μf, 10%	0160-0158	28480		1	1
C5	C: fxd, Ta, 3.3 μf, 15v	0180-0210	82376	TES 3.3M-15	1	1
C6, 8	C: fxd, my, 0.1 μf, 10%	0160-0168	28480		2	1
C7	C: fxd, Ta, 56 μf, 10%, 20v	0180-0388	56289	130D	1	1
CR5	Diode: Ge, 1N995	1910-0025	03877	1N995	1	1
CR6, 7, 9	Diode: Si	1901-0081	28480		3	3
L1	Coil: fxd, R.F., 220 mh, 5%	9140-0174	76493	9210-92	1	1

Reference Designation	Description	(hp) Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
Q3	Transistor: Ge, NPN, 2N1605A	1851-0034	82219	2N1605A	1	1
Q4	Transistor: Si, NPN	1854-0025	28480		1	1
Q5, 6	Transistor: Ge, NPN, 2N1605	1851-0031	11711	2N1605	2	1
R3	R: fxd, mtflm, 10K, 0.3w	0698-3171	28480		1	1
R15	R: fxd, mtflm, 1.00K, 1%, 1/8w, ±100 ppm /°C	0757-0280	28480		1	1
R16	R: fxd, mtflm, 180Ω, 1%, 1/8w, ±100 ppm /°C	0757-1102	28480		1	1
R17	R: fxd, mtflm, 100Ω, 1%, 1/2w, ±100 ppm /°C	0757-0198	28480		1	1
R18	R: fxd, mtflm, 5.62K, 1%, 1/8w, ±100 ppm /°C	0757-0200	28480		1	1
R19	R: fxd, mtflm, 681Ω, 1%, 1/2w, ±100 ppm /°C	0757-0816	28480		1	1
R20	R: fxd, mtflm, 196Ω, 1%, 1/2w, ±100 ppm /°C	0757-1060	28480		1	1
R21	R: fxd, mtflm, 12.1K, 1%, 1/8w, ±100 ppm /°C	0757-0444	28480		1	1
R22	R: fxd, mtflm, 1.78K, 1%, 1/8w, ±100 ppm /°C	0757-0278	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R23	R: fxd, mtflm, 17.8K, 1%, 1/8w, ±100 ppm/°C	0698-3136	28480		1	1
R24	R: fxd, mtflm, 261Ω, 1%, 1/8w, ±100 ppm /°C	0698-3132	28480		1	1
R25	R: fxd, mtflm, 1.33K, 1%, 1/4w, ±100 ppm /°C	0698-3134	28480		1	1
R26	R: fxd, mtflm, 2.61K, 1%, 1/8w, ±100 ppm/°C	0698-0085	28480		1	1
R27	R: var, ww, 1K, 10%, 0.25w	2100-0371	28480		1	1
R28	R: fxd, mtflm, 825Ω, 1%, 1/4w, ±100 ppm /°C	0757-0731	28480		1	1
R32	R: var, ww, 100Ω, 5%, 3/4w	2100-1433	28480		1	1
R33*	R: fxd, cflm, 5-40Ω to be selected by factory only when an inductor is to be substituted for C6	OBD	28480		1	
R34	R: fxd, mtflm, 51.1K, 1%, 1/8w, ±100 ppm/°C	0757-0458	28480		1	1
R35	R: fxd, mtflm, 5.11K, 1%, 1/8w, ±100 ppm/°C	0757-0438	28480		1	1
T2	Transformer: 200 μh	9130-0028	01961	3222	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
<u>A33</u>	<u>Positive Channel</u>	5060-3849	04404		1	
A33A1	Amplifier Board	OBD	04404		1	1
A33A2	Binary Printed Circuit Board**	5060-3838	04404		1	1
R1*	R: fxd, mtflm, 0-47.5K, 1/4w, factory selected	NSR	28480			
R2*	R: fxd, mtflm, 805-953K, 1/4w, factory selected	NSR	28480			
T1	Transformer: pulse, positive	NSR	04404			
<u>A33A1</u>	<u>Amplifier Board Assembly</u>					
C3	C: fxd, mica, 100 pf, 2%, 300v	0140-0176	28480		1	1
C4	C: fxd, my, 0.0056 μf, 10%	0160-0158	28480		1	1
C5	C: fxd, Ta, 3.3 μf, 15v	0180-0210	82376	TES-3.3M-15	1	1
C6, 8	C: fxd, my, 0.1 μf, 10%	0160-0168	28480		2	1
C7	C: fxd, Ta, 56 μf, 10%, 20v	0180-0388	56289	130D	1	1
CR5	Diode: Ge, 1N995	1910-0025	03877	1N995	1	1
CR6, 7, 9	Diode: Si	1901-0081	28480		3	3
L1	Coil: fxd, RF, 220 mh, 5%	9140-0174	76493	9210-92	1	1

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**See "A33A2 Binary Printed Circuit", page 5-60 for this assembly

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
Q3	Transistor: Ge, PNP, 2N404A	1850-0111	01295	2N404A	1	1
Q4	Transistor: Si, PNP, 2N3250	1853-0008	04713	2N3250	1	1
Q5, 6	Transistor: Ge, PNP, 2N404	1850-0032	02735	2N404	2	1
R3	R: fxd, mtflm, 10K, 1%, 0.3w	0698-3171	28480		1	1
R15	R: fxd, mtflm, 1.00K, 1%, 1/8w, ±100 ppm /°C	0757-0280	28480		1	1
R16	R: fxd, mtflm, 180Ω, 1%, 1/8w, ±100 ppm /°C	0757-1102	28480		1	1
R17	R: fxd, mtflm, 100Ω, 1%, 1/2w, ±100 ppm /°C	0757-0198	28480		1	1
R18	R: fxd, mtflm, 5.62K, 1%, 1/8w, ±100 ppm /°C	0757-0200	28480		1	1
R19	R: fxd, mtflm, 681Ω, 1%, 1/2w, ±100 ppm /°C	0757-0816	28480		1	1
R20	R: fxd, mtflm, 196Ω, 1%, 1/2w, ±100 ppm /°C	0757-1060	28480		1	1
R21	R: fxd, mtflm, 12.1K, 1%, 1/8w, ±100 ppm /°C	0757-0444	28480		1	1
R22	R: fxd, mtflm, 1.78K, 1%, 1/8w, ±100 ppm /°C	0757-0278	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R23	R: fxd, mtflm, 17.8K, 1%, 1/8w, ±100 ppm /°C	0698-3136	28480		1	1
R24	R: fxd, mtflm, 261Ω, 1%, 1/8w, ±100 ppm /°C	0698-3132	28480		1	1
R25	R: fxd, mtflm, 1.33K, 1%, 1/4w, ±100 ppm /°C	0698-3134	28480		1	1
R26	R: fxd, mtflm, 2.61K, 1%, 1/8w, ±100 ppm /°C	0698-0085	28480		1	1
R27	R: var, ww, 1K, 10%, 0.25w	2100-0371	28480		1	1
R28	R: fxd, mtflm, 825Ω, 1%, 1/4w, ±100 ppm /°C	0757-0731	28480		1	1
R32	R: var, ww, 100Ω, 5%, 3/4w	2100-1433	28480		1	1
R33*	R: fxd, cflm, 5-40Ω to be selected by factory only when an inductor is to be substituted for C6	OBD	28480		1	
R34	R: fxd, mtflm, 51.1K, 1%, 1/8w, ±100 ppm /°C	0757-0458	28480		1	1
R35	R: fxd, mtflm, 5.11K, 1%, 1/8w, ±100 ppm /°C	0757-0438	28480		1	1
T2	Transformer: 200 μh	9130-0028	01961	3222	1	1

Reference Designation	Description	(hp) Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A32A2, A33A2	Binary Printed Circuit Assembly**	5060-3834	04404		2	
C1, 2	C: fxd, mica, 68 pf	0140-0192	28480		2	1
CR1, 2	Diode: Si	1901-0081	28480		2	2
CR3, 4	Diode: Ge, 1N995	1910-0025	03877		2	2
Q1, 2	Transistor: Ge, PNP, 2N779A	1850-0075	56289	2N779A	2	1
R4	R: var, 200Ω, 10%, 1w	2100-0738	28480		1	1
R5*	R: fxd, mtflm, 511-750Ω, 1%, 1/4w	NSR	28480			
R6*	R: fxd, mtflm, 178-464Ω, 1%, 1/4w	NSR	28480			
R7, 8	R: fxd, mtflm, 681Ω, 1%, 200v	0698-3133	28480		2	1
R9, 10	R: fxd, mtflm, 5.62K, 1%, 1/8w	0757-0200	28480		2	1
R11, 12	R: fxd, mtflm, 21.5K, 1%, 1/8w	0757-0199	28480		2	1
R13, 14	R: fxd, mtflm, 1.50K, 1%, 1/8w	0757-0427	28480		2	1
R31	R: fxd, mtflm, 2.74K, 1%, 200v	0698-3135	28480		1	1
R36*	R: fxd, mtflm, 5.62-51.1K, selected by factory as pad for R5	OBD	28480		1	
R37*	R: fxd, mtflm, 1.78-51.1K, selected by factory as pad for R6	OBD	28480		1	

M0185 *NOTE: 1/4w to be conformal types only

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A34	Series Regulator	5060-3782				
C3, 5	C: fxd, elect, 75 μf, 30v	0180-0362	56289	34D756H030 EJ4	2	1
C4	C: fxd, mica, 1500 pf, 2%, 300v	0140-0156	04062	DM15F152J	1	1
CR1-8	Diode: Si	1901-0081	28480		8	8
Q1, 3	Transistor: Si, NPN, 2N3053	1854-0039	28480		2	1
Q2	Transistor: Si, NPN	1854-0003	28480		1	1
R1	R: fxd, mtflm, 215Ω, 1%, 1/4w, 100 ppm /°C	0698-0088	28480		1	1
R2	R: fxd, mtflm, 464Ω, 1%, 1/2w, 100 ppm /°C	0698-0090	28480		1	1
R3	R: fxd, cflm, 6Ω, 1%, 1/2w	0727-0704	28480		1	1
R4	R: fxd, mtflm, 10.0K, 1%, 1/8w, 100 ppm /°C	0757-0442	28480		1	1
R5	R: fxd, mtflm, 316Ω, 1%, 1/4w, 100 ppm /°C	0698-0087	28480		1	1
R6	R: fxd, mtflm, 10Ω, 1w	0698-0093	28480		1	1
R7	R: fxd, mtflm, 1.00K, 1%, 1/4w, 100 ppm /°C	0757-0338	28480		1	1
R8	R: fxd, mtflm, 2.87K, 1%, 1/4w, 100 ppm /°C	0698-0086	28480		1	1

M0185

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R9	R: fxd, mtflm, 3.32K, 1%, 1/4w	0757-0743	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A35	Power Supply Amp.	5060-3783				
C1	C: fxd, my, 0.1 μf, 10%	0160-0168	28480		1	1
C2	C: fxd, my, 0.033 μf, 10%	0160-0163	28480		1	1
C3	C: fxd, mica, 56 pf, 5%, 300v	0140-0191	04062	DM15E560J	1	1
C4	C: fxd, Ta, 56 μf, 15v	0180-0196	01295	SCM566GP015D2	1	1
CR1	Diode: Selected	5080-1471	04404		1	1
CR3	Zener resistor set, matched	NSR	04404	5080-4004	1	1
CR4	Diode: Si	1901-0156	28480		1	1
Q1, 2	Transistor: Si, PNP, 2N3250	1853-0008	04713	2N3250	2	1
Q3, 5	Transistor: PNP	1853-0009	28480		2	1
Q4, 8	Transistor: Si, NPN	1854-0003	28480		2	1
Q6, 7, 10, 11	Transistor: Si, NPN, dual	1854-0014	28480		4	2
Q9	Transistor: Si, PNP	1853-0001	28480		1	1
R1	R: fxd, mtflm, 3.32K, 1%, 1/8w, ±100 ppm /°C	0757-0433	28480		1	1
R2	R: fxd, mtflm, 2.15K, 1%, 1/8w, ±100 ppm /°C	0698-0084	28480		1	1
R3	R: fxd, mtflm, 825Ω, 1%, 1/8w	0698-0091	28480		1	1

Reference Designation	Description	(hp) Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R4	R: fxd, mtflm, 464Ω, 1%, 1/8w, ±100 ppm /°C	0698-0082	28480		1	1
R5	R: fxd, mtflm, 27.4K, 1%, 1/8w, ±100 ppm /°C	0757-0452	28480		1	1
R6, 7, 11, 23, 27	R: fxd, mtflm, 10.0K, 1%, 1/8w, ±100 ppm /°C	0757-0442	28480		5	2
R8, 10	R: fxd, ww, 825Ω, 0.1%, 1/4w, 2.5 ppm/°C	0811-0961	28480		2	1
R9	R: var, ww, 200Ω, 5%	2100-1420	28480		1	1
R12, 13	R: fxd, ww, 1K, .25%, 2.5 ppm/°C	0811-0963	28480		2	1
R14, 15	R: fxd, mtflm, 1.21K, 1%, 1/8w, ±100 ppm /°C	0757-0274	28480		2	1
R16	R: fxd, mtflm, 3.01K, 1%, 1/8w, ±100 ppm /°C	0757-0273	28480		1	1
R17	R: fxd, mtflm, 2.87K, 1%, 1/4w, ±100 ppm /°C	0698-0086	28480		1	1
R18	R: fxd, ww, 738Ω, 1%, 5 ppm/°C	0811-0962	28480		1	1
R19	R: fxd, mtflm, 1K, 1%, 1/8w, ±100 ppm/°C	0757-0280	28480		1	1
R21	R: var, ww, 100Ω, 25 ppm/°C	2100-1433	28480		1	1
R24	R: fxd, mtflm, 2.61K, 1%, 1/8w, ±100 ppm /°C	0698-0085	28480		1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
R25, 26	R: fxd, mtflm, 2.61K, 1%, 1/8w, ±25 ppm /°C	0698-0092	28480		2	1
R28	R: fxd, mtflm, 243Ω, 1%, 1/8w, ±100 ppm /°C	0757-0408	28480		1	1
R29	R: fxd, mtflm, 487Ω, 1%, 1/8w, ±100 ppm /°C	0698-3178	28480		1	1
R30	R: fxd, ww, 11Ω, .5%, 20 ppm/°C	0811-0995	28480		1	1

M0185

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A36	Rectifier Filter Board	5060-3806	04404			
C1, 3	C: fxd, elect, 250 μf, 30v	0180-0364	56289	34D257H030GJ4	2	1
C2, 4, 6	C: fxd, cer, .01 μf, 20%, 1000v	0150-0012	56289	29C214A3	3	1
C5	C: fxd, elect, 150 μf, 30v	0180-0363	56289	34D157H030FJ4	1	1
C7, 8	C: fxd, elect, 10 μf, 350v	0180-0361	56289	34D106G350FJ4	2	1
C9, 10	C: fxd, selected in test (within range of 5.170K-5.310K)	OBD	04404		2	1
CR1-6	Diode: Si	1901-0026	28480		6	6
CR7	Diode: Si	1901-0036	28480		1	1
R1	R: fxd, comp, 680K, 5%, 1/2w	0686-6845	01121	EB6845	1	1
R2	R: fxd, 6.8K, 5%, 1/2w	0686-6825	01121	EB6825	1	1

Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
A47	Relay Time Circuit	5060-3691	04404			
C1	C: fxd, my, 0.047 μf, 10%	0170-0040	28480		1	1
C2	C: fxd, elect, 8 μf, 30v	0180-0010	21520	PP8B30A2	1	1
CR1	Diode: Si	1901-0025	28480		1	1
Q1	Transistor: Ge, NPN, 2N388A	1851-0024	01295	2N388A	1	1
R1, 3	R: fxd, comp, 2.2K, 5%, 1/4w	0683-2225	01121	CB2225	2	1
R2	R: fxd, comp, 270Ω, 5%, 1/4w	0683-2715	01121	CB2715	1	1
R4	R: fxd, comp, 8.2K, 5%, 1/2w	0686-8225	01121	EB8225	1	1

M0185

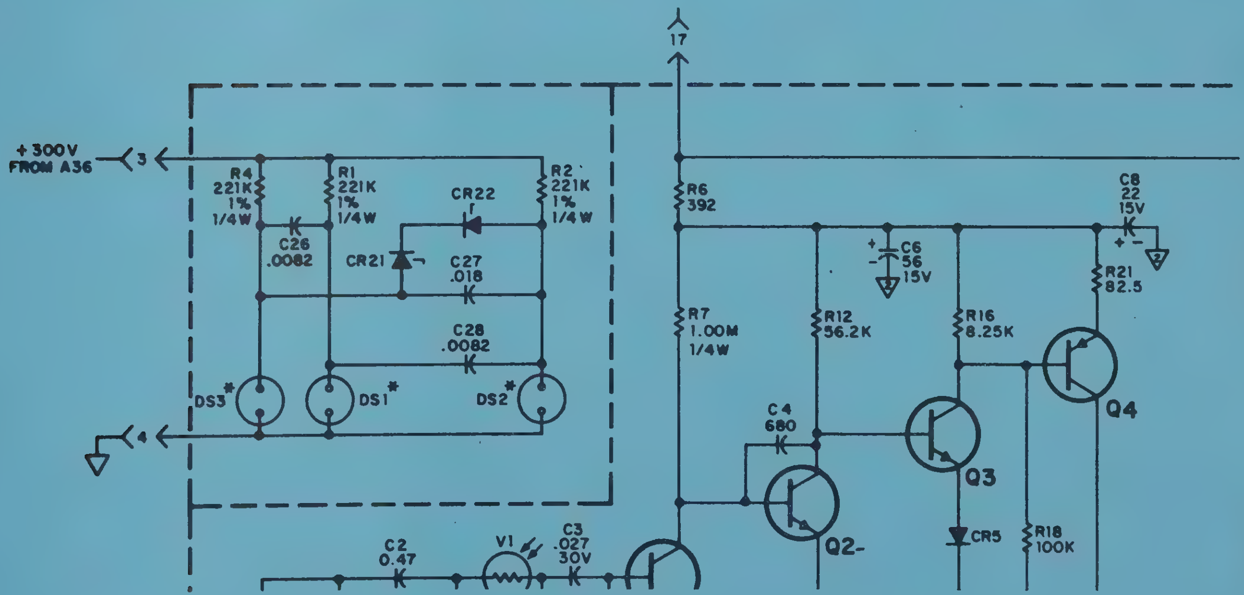
Reference Designation	Description	hp Stock No.	Mfr. Code	Mfr. Part No.	Qty.	1-Yr. Spa.
	<u>Neon Block Assembly</u>	5060-5019	04404			
DS1-6	Lamp: glow, gas filled	2140-0044	74276	A016	6	2
R1	R: fxd, comp, 270K, 5%, 1/4w	0683-2745	01121	CB2745	1	1
V1	Photoconductor: 6 element	1990-0016	28480		1	1

HANDBOOK
BACKDATING SUPPLEMENT

for

MODEL DY-2401C
INTEGRATING
DIGITAL VOLTMETER

ITEM	DESCRIPTION
1	Page 4-93, Fig. 4.50, A34 Portion of Schematic. Capacitor C4 was 470 pf on instruments 501-00021, 25-27, 30-35, 41, 42, 45, 48, 50-52, 54, 55, 58, 59, 61, 63, 65-70. If C4 must be replaced, use the 1500 pf capacitor specified in the parts list.
2	Page 4-89, Fig. 4.46, Upper Left Portion of Circuit. Early production units with serial prefix 501- may have a 3-neon chopper oscillator circuit, as follows:



3 Page 5-32, CR4 Stock Number. Should read 1910-0037.

HANDBOOK
UPDATING SUPPLEMENT

for

MODEL DY-2401C
INTEGRATING
DIGITAL VOLTMETER

ITEM	DESCRIPTION
1	Page 5-50: Insert or change specific entries to read as follows:

Ref. Des.	Description	Stock No.	Qty.
C28	C: fxd, my, value .0012 μf to .0082 μf (selected in test as pad for C27), 10%, 200v	OBD	1
R2, 4	R: fxd, mtflm, 182K or 187K, 1%, 1/4w	OBD	2

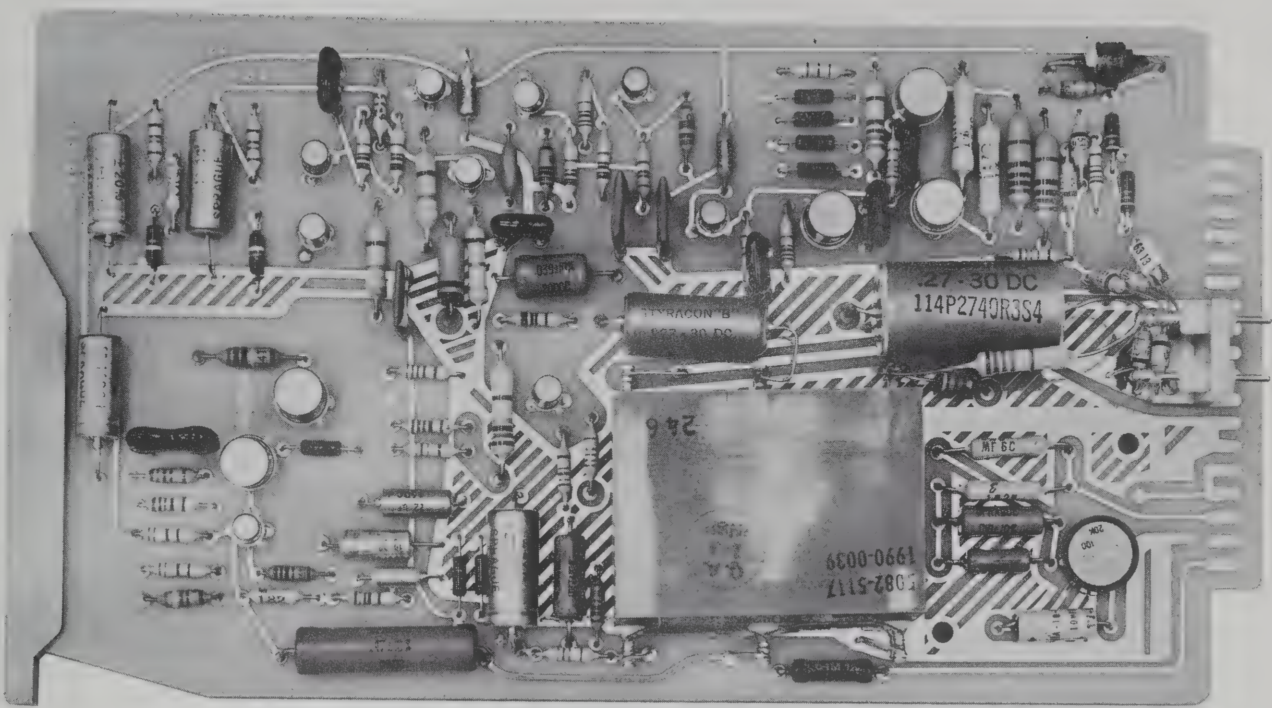
--Note--
Items 2a through 2k, which follow, apply to DY-2401C instruments with serials prefixed 521-.

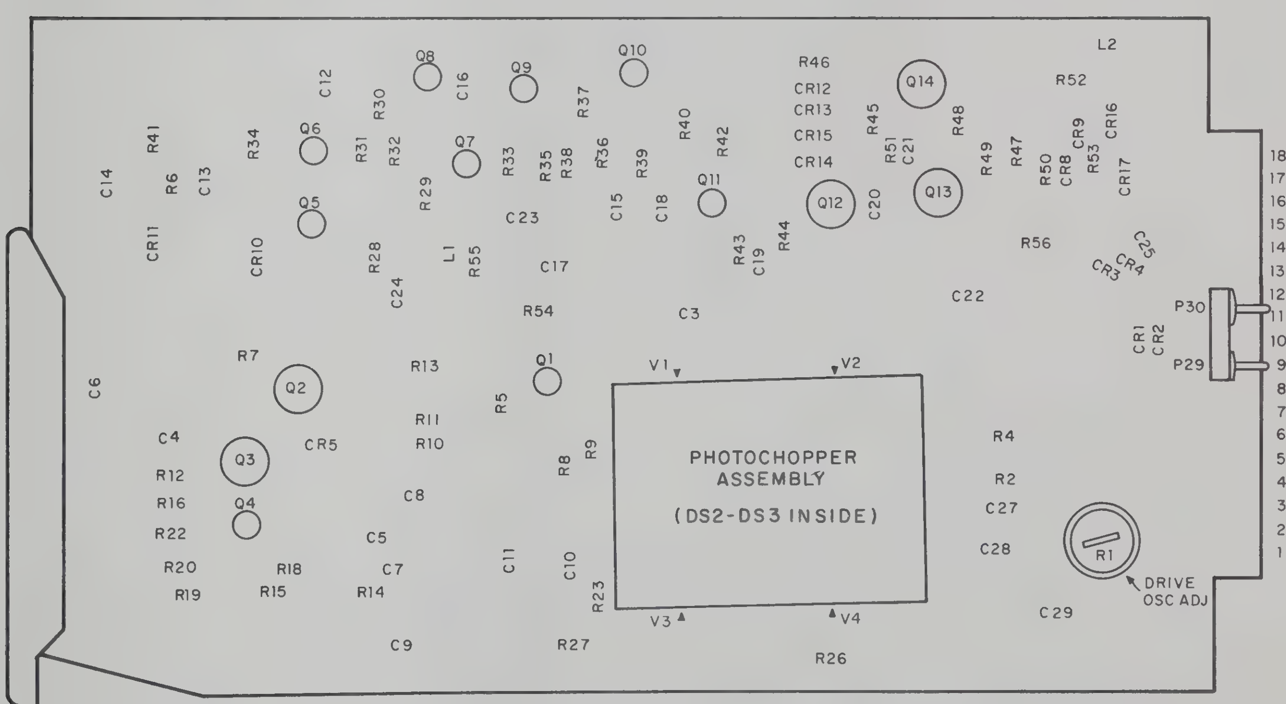
2a Page 3-7: Replace first 8 lines at top of page with the following:

driven by flashes of light from the neon bulbs of a relaxation oscillator. The oscillator frequency is set by R1 to be 240 cps at nominal power line voltage (115 or 230 vac). The photochopper mechanical equivalent is shown in Figure 3.2. After filtering, the signal from demodulating photochoppers V3 and V4 is a smooth, amplified and inverted replica of the dc and low fre-

ITEM	DESCRIPTION (DY-2401C Integrating Digital Voltmeter)
2a	quency components of the signal at the summing point. This output is applied to one input of the wideband amplifier. The choppper amplifier output is prevented from exceeding ±0.5 volts by CR6 and CR7.
2b	Page 4-39, Figure 4.5: Delete the caption: DRIVE OSC ADJ.
2c	Page 4-47, Section 4.7.10 Photochopper Drive Oscillator Adjustment: Change to read as follows: The DRIVE OSC ADJustment (R1) on assembly A31 (see revised Figure 4.45) sets the frequency of the photochopper drive oscillator. This frequency should be 240 ±5 cps when line voltage to the DY-2401C is at design center (115 or 230 vac). The frequency may be counted through a high impedance probe at either lead of A31C27 if the driver oscillator cover is removed.
2d	Page 4-88, Figure 4.45: Replace with revised Figure 4.45 (attached).
2e	Page 4-89, Figure 4.46: Replace with revised Figure 4.46 (attached).
2f	Page 5-3: Change stock number of A31 Operational Amplifier from 5060-3848 to 5060-5145.
2g	Page 5-6: Change stock number of A31 as noted in Item 2f.
2h	Page 5-49: Change stock number of A31 as noted in Item 2f.
2i	Page 5-50: Insert specific entries to read as follows:

Ref. Des.	Description	Stock No.	Qty.
C29	C: fxd, Ta, 10 μf, -15/+20%, 60v	0180-0079	1
R1	R: var, ww, 20K	2100-0364	1

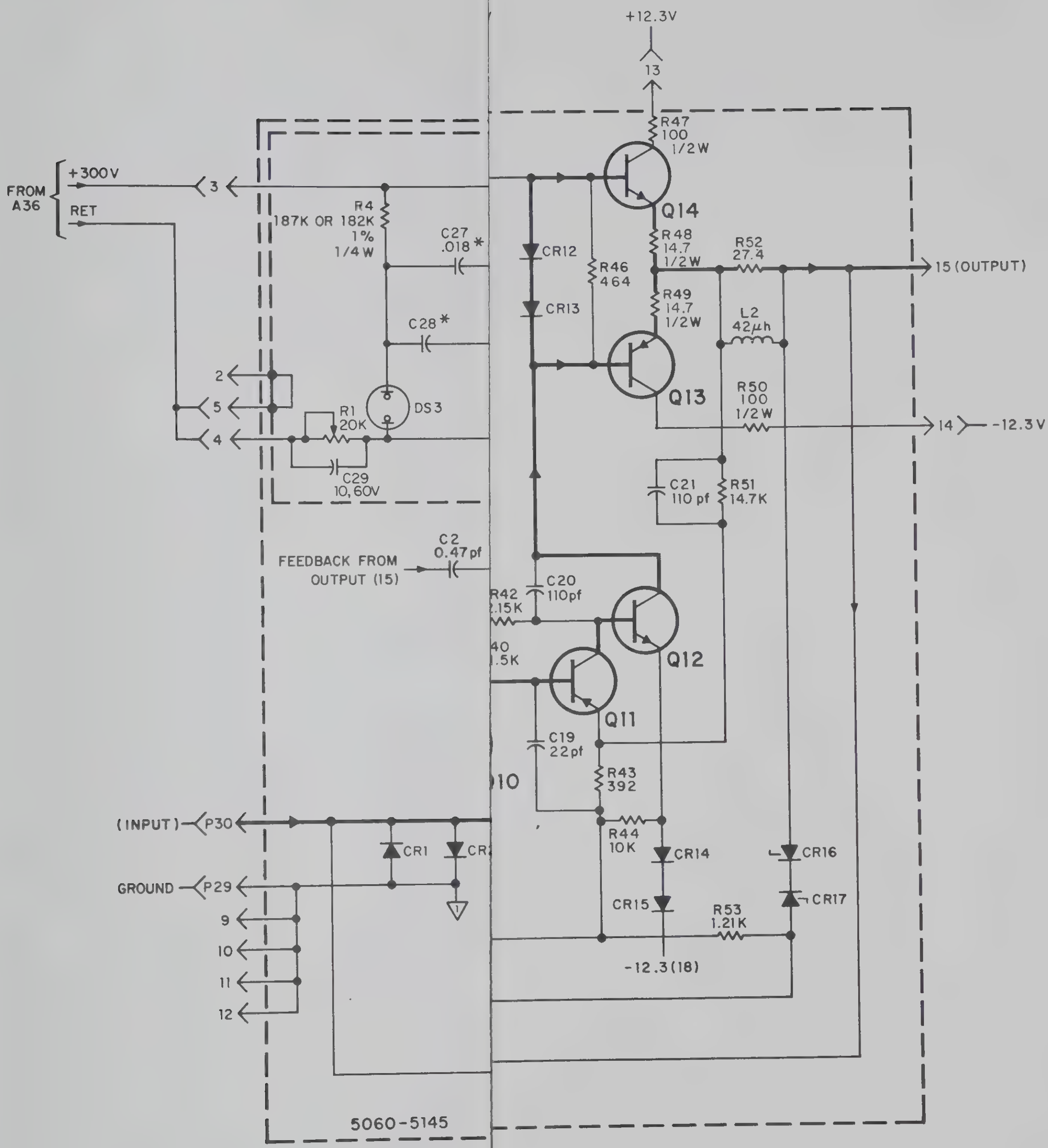




INTEGRATING OPERATIONAL AMPLIFIER ASSEMBLY (A31)

(5060-5145)

FIGURE 4.45



NOTES:

UNLESS OTHERWISE NOTED:

1. a. ALL RESISTORS 1/8 W ± 5%
   b. ALL CAPACITANCE IN MICROFA
2. TAPEMASTER DWG. NO. C5080
3. ASSEMBLY DWG. NO. C5060-

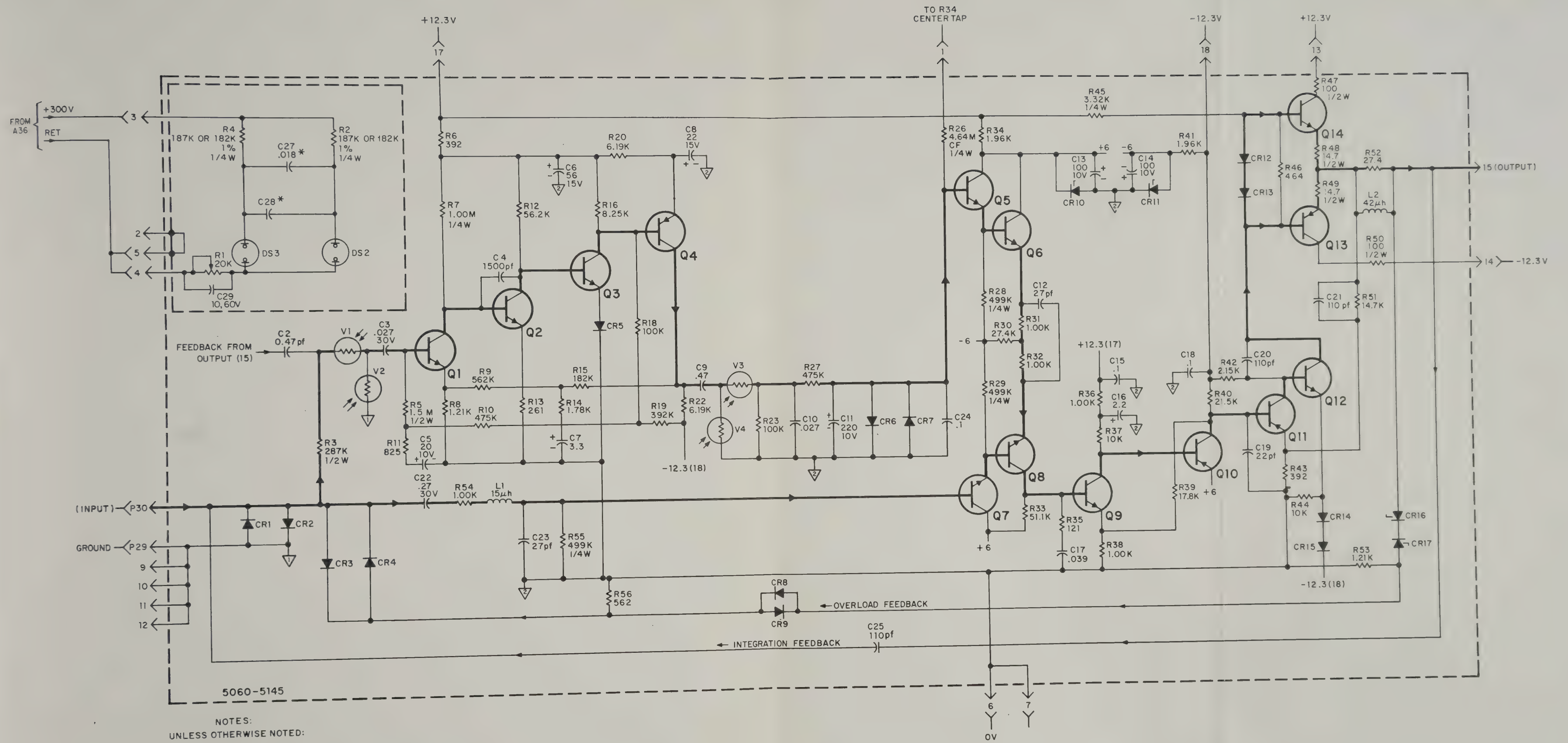
* SELECTED FOR OSCILLATOR FR

D5060-5145

INTEGRATING AMPLIFIER (A31)

(Serials Prefixed 521-)

FIGURE 4.46



NOTES:
UNLESS OTHERWISE NOTED:

1. a. ALL RESISTORS 1/8 W ±5%
   b. ALL CAPACITANCE IN MICROFARADS
2. TAPEMASTER DWG. NO. C5080-2836
3. ASSEMBLY DWG. NO. C5060-5145

* SELECTED FOR OSCILLATOR FREQUENCY OF 240 CPS

D5060-5145

INTEGRATING AMPLIFIER (A31)

(Serials Prefixed 521-)

FIGURE 4.46

ITEM	DESCRIPTION (DY-2401C Integrating Digital Voltmeter)
2j	Page 5-51: Change specific entries to read as follows:

Ref. Des.	Description	Stock No.	Qty.
R16	R: fxd, mtflm, 8.25K, 1%, 1/8w	0757-0441	1
R20, 22	R: fxd, mtflm, 6.19K, 1%, 1/8w	0757-0290	2

2k Page 5-52: Change R48, 49 entry to read as follows:

Ref. Des.	Description	Stock No.	Qty.
R48, 49	R: fxd, mtflm, 14.7Ω, 1%, 1/8w	0698-3388	2

6/15/65

--Note--
Items 3a through 3d, which follow, apply to DY-2401C instruments with serials prefixed 526-.

3a Page 4-71, Figure 4.28: Replace with revised Figure 4.28 (attached).

3b Page 5-28: Change C7 entry to read as follows:

Ref. Des.	Description	Stock No.	Qty.
C7	C: fxd, mica, 1000 pf, 5%	0160-0938	1

3c Page 5-30: Change CR3-6 entry in Reference Designation Column to read CR3, 5, 6 (CR4 is replaced by a 1K resistor, see item 3d).

3d Page 5-31: Add R25 entry to read as follows:

Ref. Des.	Description	Stock No.	Qty.
R25	R: fxd, comp, 1K, 5%, 1/4w	0683-1025	1

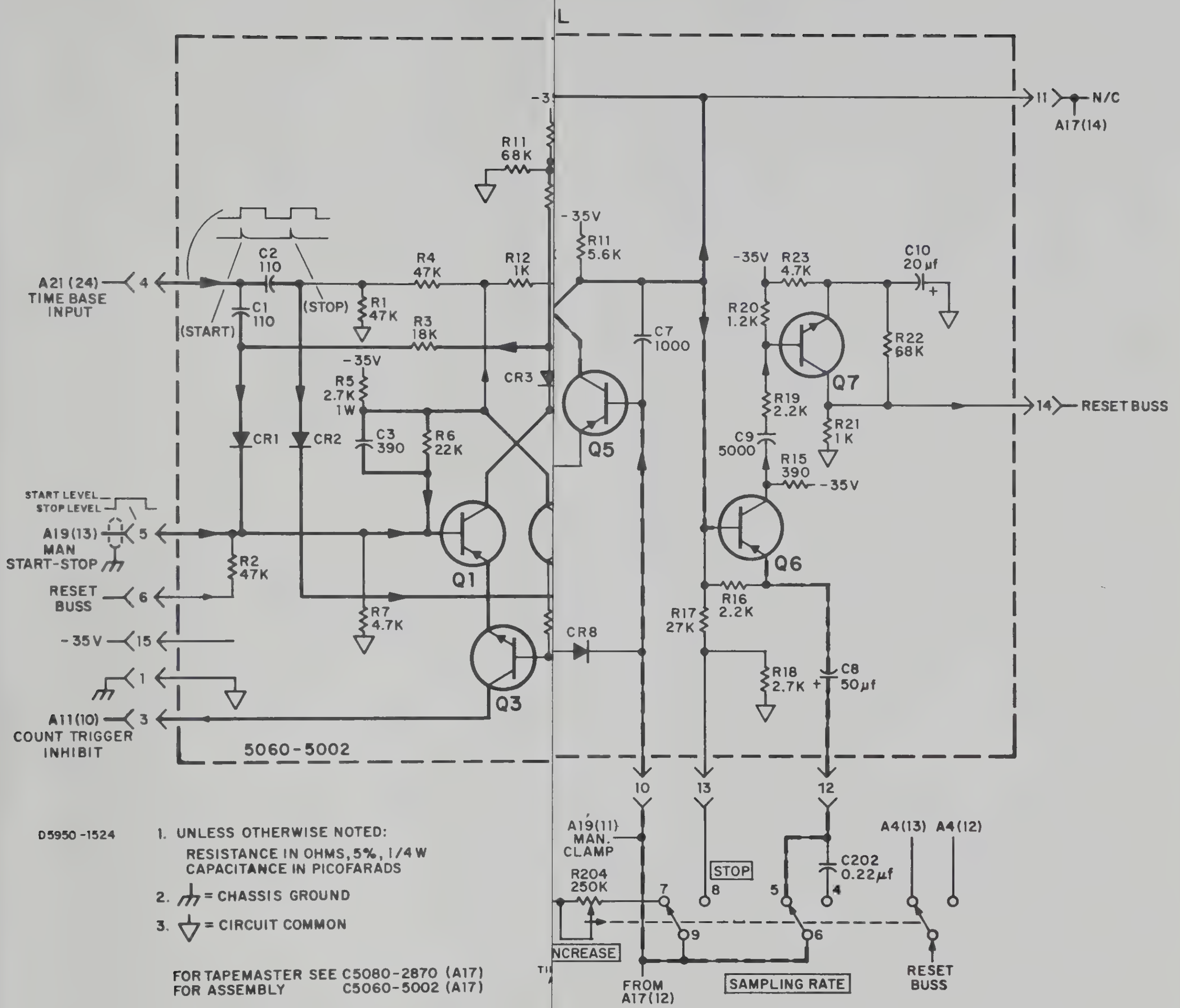
--Note--
Item 3e, which follows, applies to DY-2401C-M31 instruments with serials prefixed 526-.

3e Replace circuit diagram D5060-5021, which is furnished with the M31 handbook supplement, with the revised D5060-5021 (attached).

7/19/65

ITEM	DESCRIPTION
	--Note-- Items 4a and 4b, which follow, apply to DY-2401C instruments with serials prefixed 529- and may also apply to certain DY-2401C instruments with serials prefixed 501. Verify stock number of transformer T2 to make certain of ordering the correct replacement.
4a	Page 4-93: Replace Figure 4.50 with revised Figure 4.50 (attached).
4b	Page 5-10: Change stock number of T2 to 9100-1211.
5a	Page 4-87: Figure 4.44, Programmable Attenuator and V-F Converter Circuit (A28, A31, A32 & A33): Please interchange the power supply voltages shown connected to A32, pins 8 and 9; -12.3V should go to pin 8 and +12.3V should go to pin 9 of A32 in this figure
5b	Page 4-93: Figure 4.50, Power Supply Circuit (A34, A35 & A36), please correct to show that +12.3V goes to A33(9) and A32(9) and that -12.3V goes to A33(8) and A32(8)

7/24/65



D5950-1524

1. UNLESS OTHERWISE NOTED:
   RESISTANCE IN OHMS, 5%, 1/4 W
   CAPACITANCE IN PICOFARADS
2. = CHASSIS GROUND
3. = CIRCUIT COMMON

FOR TAPEMASTER SEE C5080-2870 (A17)
FOR ASSEMBLY C5060-5002 (A17)

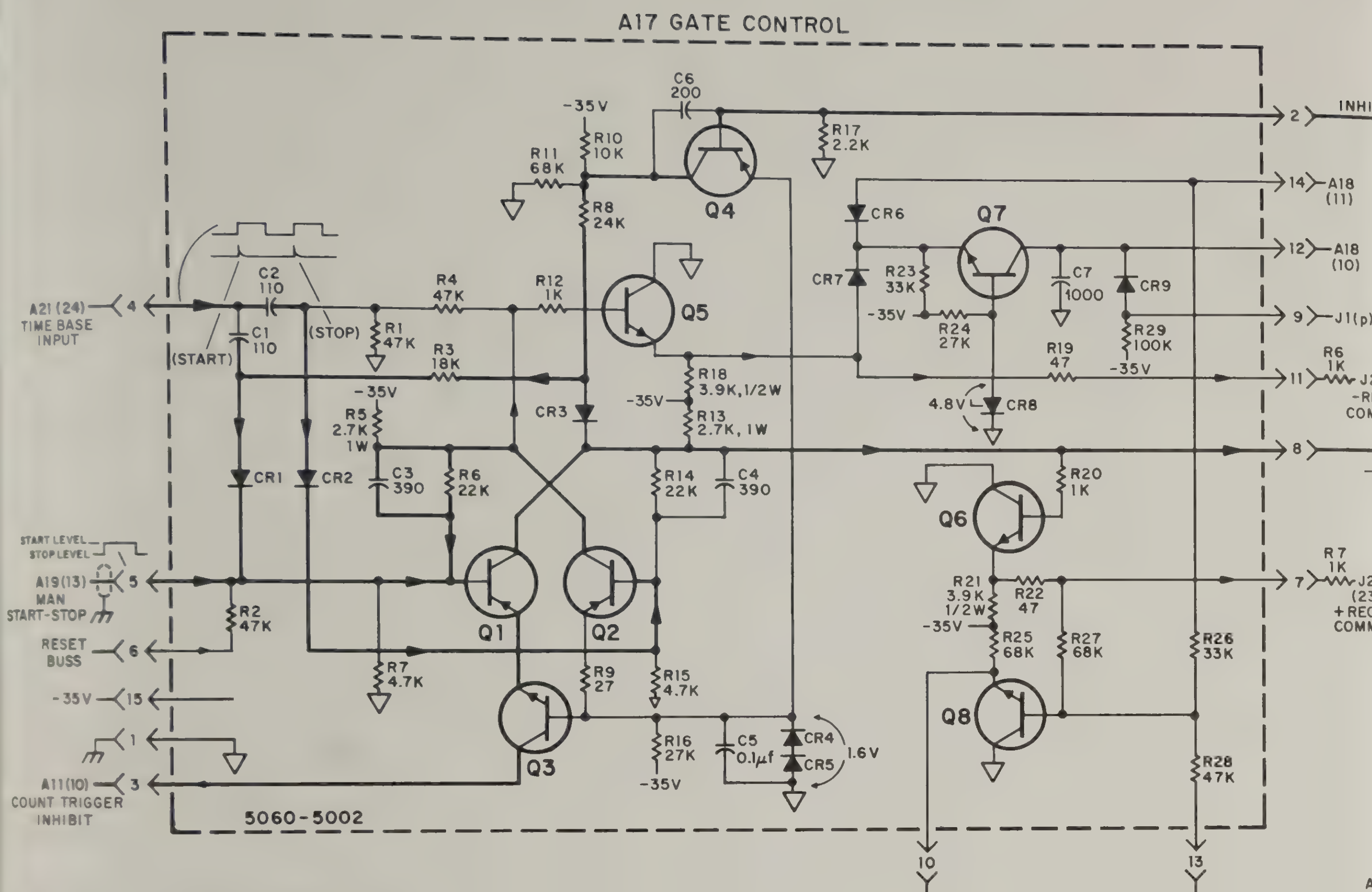
GATE AND DISPLAY CONTROL CIRCUITS (A17 & A18)

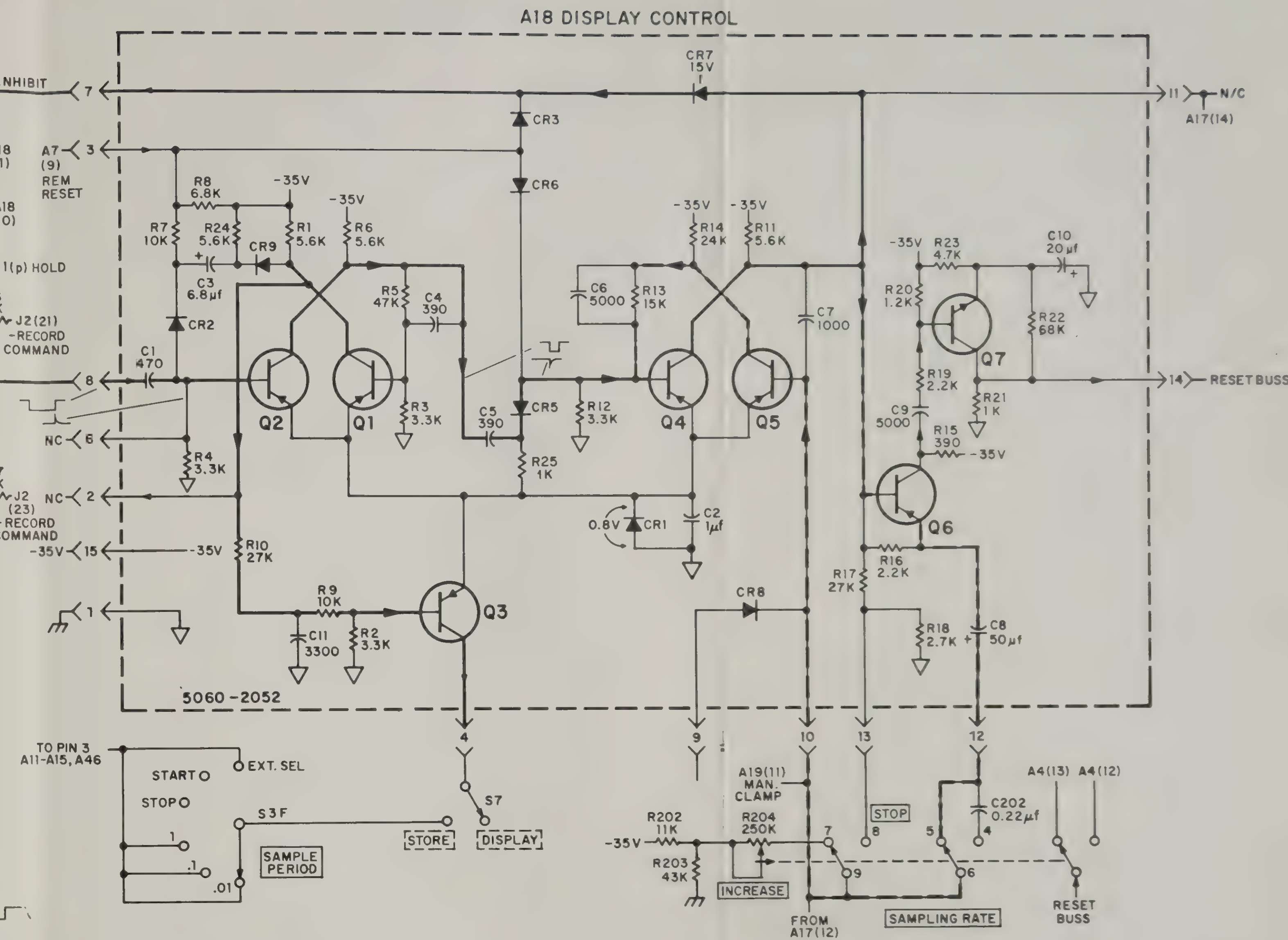
(SERIALS PREFIXED 526-)

FIGURE 4.28

ITEM	DESCRIPTION
	--Note-- Items 4a and 4b, which follow, apply to DY-2401C instruments with serials prefixed 529- and may also apply to certain DY-2401C instruments with serials prefixed 501. Verify stock number of transformer T2 to make certain of ordering the correct replacement.
4a	Page 4-93: Replace Figure 4.50 with revised Figure 4.50 (attached).
4b	Page 5-10: Change stock number of T2 to 9100-1211.
5a	Page 4-87: Figure 4.44, Programmable Attenuator and V-F Converter Circuit (A28, A31, A32 & A33): Please interchange the power supply voltages shown connected to A32, pins 8 and 9; -12.3V should go to pin 8 and +12.3V should go to pin 9 of A32 in this figure
5b	Page 4-93: Figure 4.50, Power Supply Circuit (A34, A35 & A36), please correct to show that +12.3V goes to A33(9) and A32(9) and that -12.3V goes to A33(8) and A32(8)

7/24/65



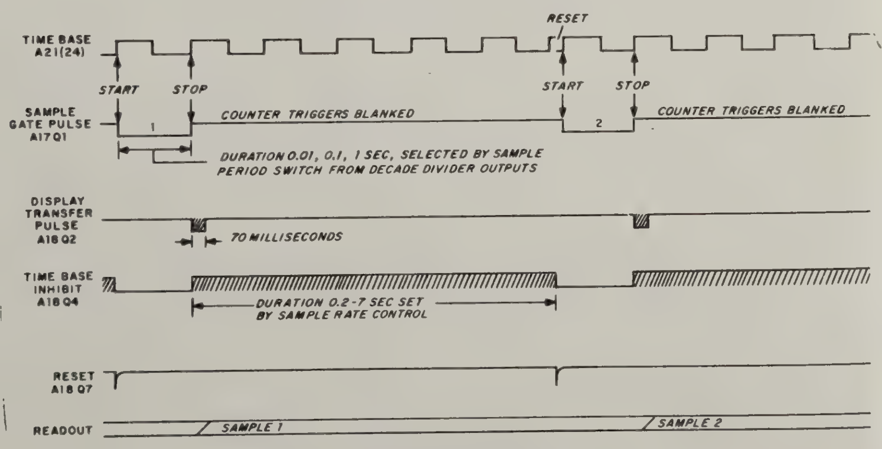


05950-1524

1. UNLESS OTHERWISE NOTED:
   RESISTANCE IN OHMS, 5%, 1/4 W
   CAPACITANCE IN PICOFARADS
2. = CHASSIS GROUND
3. = CIRCUIT COMMON

FOR TAPEMASTER SEE C5080-2870 (A17)
FOR ASSEMBLY C5060-5002 (A17)

MEASUREMENT/ DISPLAY TIMING



NOTE: WAVESHAPES ARE IDEALIZED; DURATIONS OF BRIEF PULSES ARE NOT TO SCALE

GATE AND DISPLAY CONTROL CIRCUITS (A17 & A18)

(SERIALS PREFIXED 526-) FIGURE 4.28

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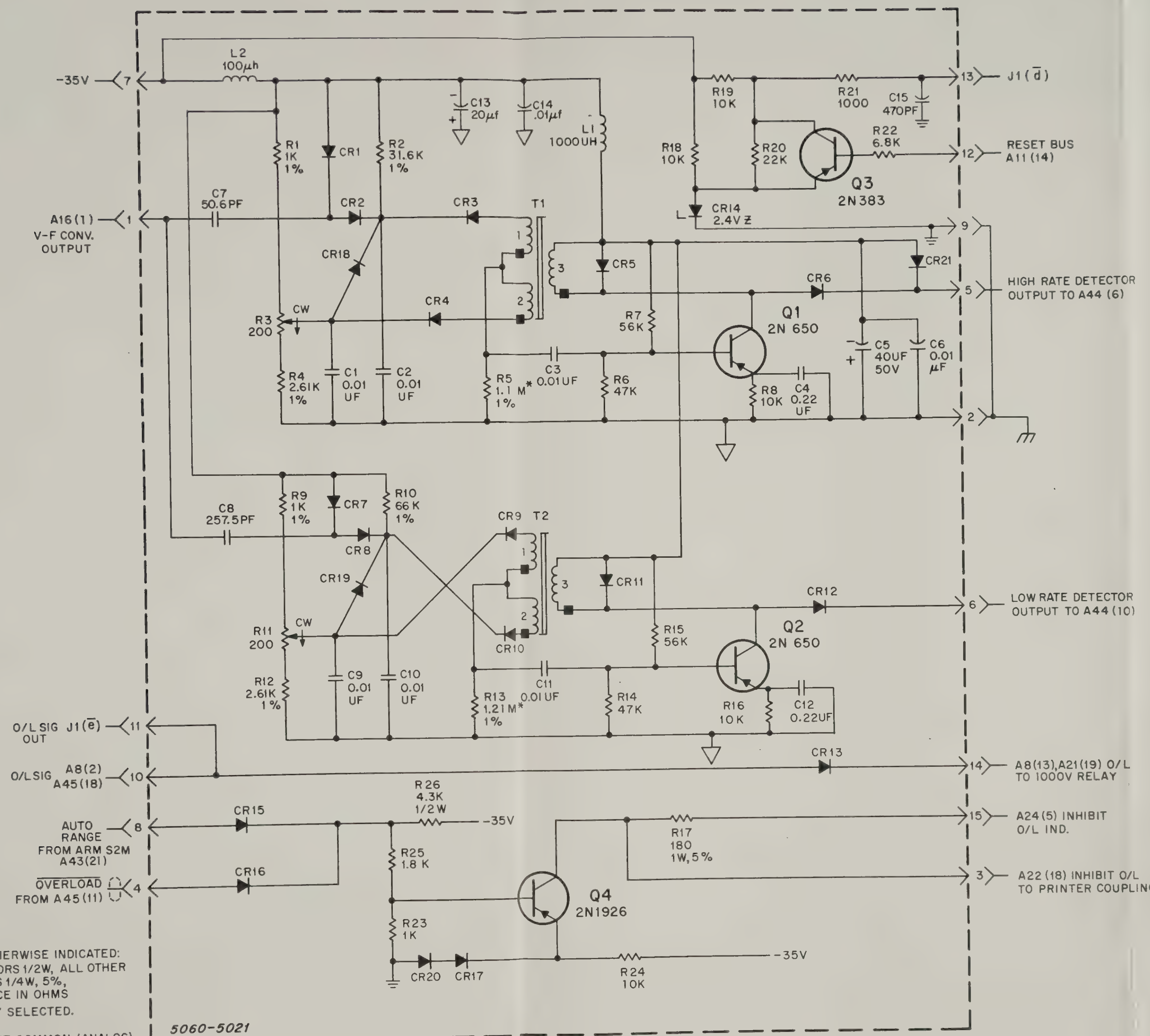
DY-2401C-M31 INTEGRATING DIGITAL VOLTMETER A10 AUTO-RANGE RATE DET.	DYMEC A DIVISION OF HEWLETT-PACKARD CO PALO ALTO, CALIFORNIA	
	D5060-5021	
SCALE	CODE 04404	SHEET 1 OF 2

A10 AUTO-RANGE RATE DETECTOR



NOTES

1. UNLESS OTHERWISE INDICATED: 1% RESISTORS 1/2W, ALL OTHER RESISTORS 1/4W, 5%, RESISTANCE IN OHMS
2. ∗ = FACTORY SELECTED.
3. ▽ = CIRCUIT COMMON (ANALOG)
   ⏚ = CHASSIS GROUND
   ⏚ = CIRCUIT COMMON (DIGITAL)
4. SHEET 2 ON 'C' SIZE

D5060-5021

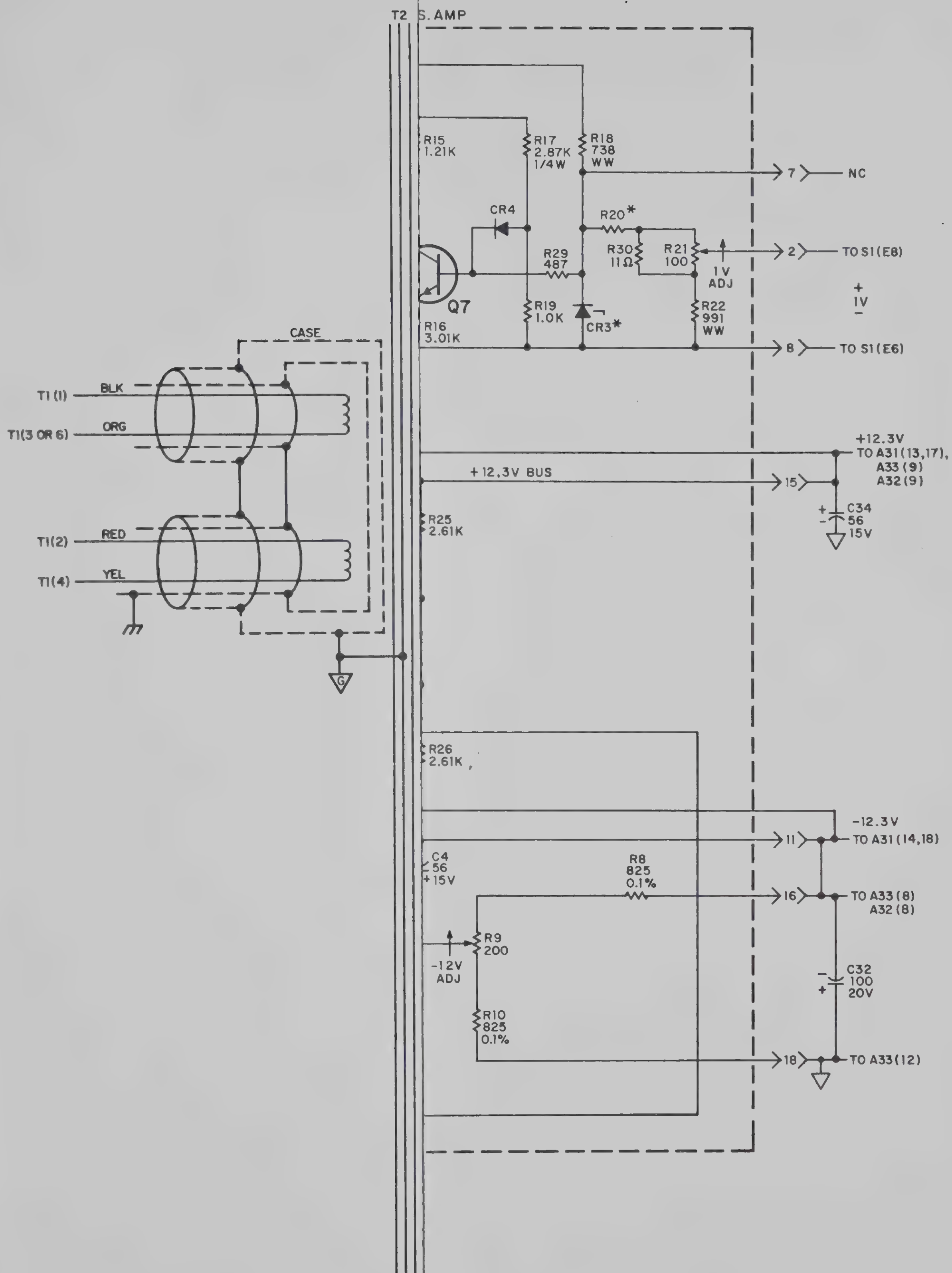
DY-2401C-M31 INTEGRATING DIGITAL VOLTMETER

A10 AUTO-RANGE RATE DETECTOR

SERIALS PREFIXED 526 –

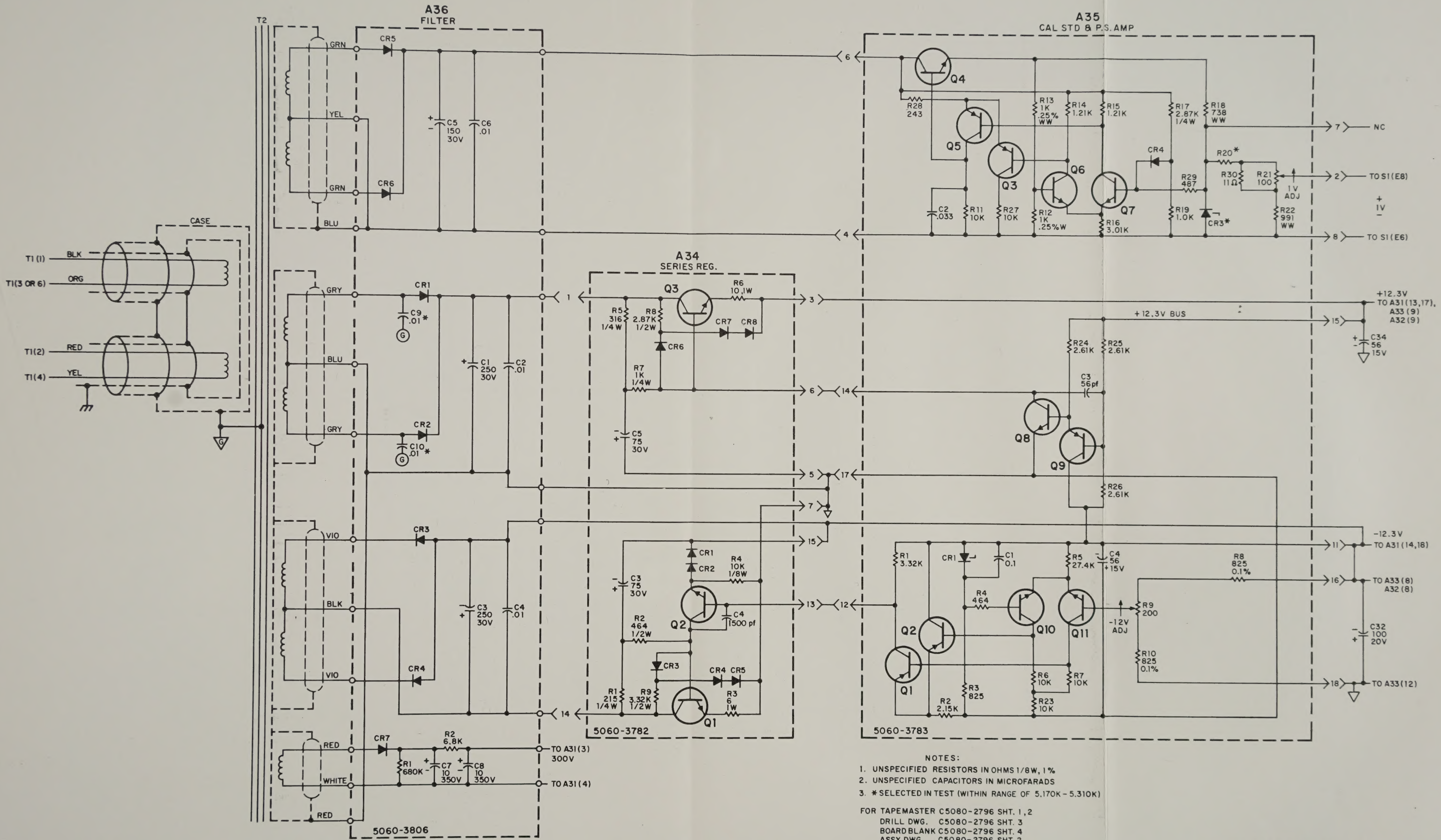
DY-2401C-M31

DY-2401C-M31 INTEGRATING DIGITAL VOLTMETER A10 AUTO-RANGE RATE DET.	DYMEC A DIVISION OF HEWLETT PACKARD CO PALO ALTO CALIFORNIA
	D5060-5021
SCALE	CODE 04404 SHEET 1 OF 2



POWER SUPPLY CIRCUIT
(A34, A35 & A36)

(SERIALS PREFIXED 529-) **FIGURE 4.50**



NOTES:
1. UNSPECIFIED RESISTORS IN OHMS 1/8W, 1%
2. UNSPECIFIED CAPACITORS IN MICROFARADS
3. ∗ SELECTED IN TEST (WITHIN RANGE OF 5.170K–5.310K)

FOR TAPEMASTER C5080-2796 SHT. 1, 2
DRILL DWG. C5080-2796 SHT. 3
BOARD BLANK C5080-2796 SHT. 4
ASSY DWG. C5080-2796 SHT. 2

POWER SUPPLY CIRCUIT
(A34, A35 & A36)

(SERIALS PREFIXED 529-) **FIGURE 4.50**

HEWLETT PACKARD DYMEC DIVISION

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